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THE NATIONAL ENGINEERING SCHOOL OF MEXICO.

By MANSFIELD MERRIMAN.*

The sessions of the thirty-ninth annual convention of the American Society of Civil Engineers were held in July, 1907, in the City of Mexico, in the building called "El Mineria," which is occupied by the National Engineering School of Mexico. The name of the building is derived from the Colegio de Mineria, or School of Mines, which was undoubtedly the first institution founded for engineering instruction on the western continent, its formal opening having taken place on Jan. 1, 1792. In 1868 the scope of this mining school was enlarged by the addition of courses in other branches of engineering, and its name was then changed to La Escuela Nacional de Ingenieros.

A view showing the north front and the west side of the Mineria is given in Fig. 1, the lengths of these sides being 89 and 81 meters, respectively (290 and 265 ft.). The downward curvatures of the cornice lines and of the floor lines are due to a sinking of the foundations of the building. This sinking has been the greatest near the central parts of the building and the least at the corners, the former being now more than one foot in excess of the latter, so that all of the floors have a marked slope. While this distortion has produced some cracks in the ceilings and interior walls, there are few visible elsewhere, owing to the excellence of the joints and bond of the masonry. The soft, light sandstone, so commonly seen in Mexico, is used throughout the building.

The plans of the two floors, Figs. 2 and 3, show the interior arrangement. About one-half of the lower floor and one-fifth of the upper floor are not at present used by the engineering school, being occupied by the law school and by offices of the Mexican government; these portions are distinguished on the plans by cross hatching.

Entering the building through the portal hall, the visitor passes into the beautiful principal court, which is 24.3 × 24.3 meters (80 × 80 ft.) in the clear between the columns, and 33.4 × 33.4 meters (110 × 110 ft.) between the corridor walls. At the south side of this court two stairways lead up to the second floor, and, passing along the upper corridors, access is had to the rooms where the larger part of the work of the school is done. The columns and paneled walls bounding these corridors produce a fine architectural effect, and upon the occasion of the reception tendered to the American Society of Civil Engineers, on July 13, this effect was highly enhanced by beautiful floral decorations. Fig. 4 gives a view of this main court which shows the excellent masonry work in the arches, while one of the stairways leading to the second floor is seen in the background.

The history of this engineering college begins in 1771, when the miners' guild of New Spain petitioned the Spanish crown that a portion of the tax levied upon silver bullion might be devoted to the establishment of a school for giving instruction in mining operations. On May 22, 1783, a royal decree assenting to this petition was issued, and the erection of a building ordered. On Jan. 1, 1792, the formal organization of the Colegio de Mineria was effected with pompous ceremony, and its course of studies was then inaugurated in a building on the Street Hospicio de San Nicolas. The construction of the present building on the Street San Andres was begun in 1797, under plans prepared by the architect Manuel Tolsa, and it was completed in 1813 at a cost of $937,166 in Mexican money. From 1792 to 1843 the instruction related mostly to mining operations. In 1843 its scope was rendered broader by the introduction of special courses in surveying, assaying and smelting and geology. Prior to 1868 there was also conducted in the same building and under the same organization a preparatory school for those who desired to enter the higher technical courses.

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THE NATIONAL ENGINEERING SCHOOL OF MEXICO.

Another ancient technical college in the City of Mexico is that of the school of architecture, which is affiliated with the national museum of art. A course in civil engineering was organized and conducted in this school for several years prior to 1868, but in that year it was transferred to the mining college, which then became the National Engineering School. The preparatory branches were at this time placed under another organization, courses in various branches of technology were established, and the school has since experienced a marked growth, and has exercised a great influence upon the industrial progress of Mexico.

The requirements for admission to this school are that the ground of the courses of the national preparatory school shall have been covered, especially of its three years' work in mathematics and its two years' work in the sciences. This preparation includes geometry, elementary algebra and plane trigonometry, and in general appears to be of the same grade as that required for admission to engineering colleges in the United States. Tuition is entirely free, and the privileges of the school are open to all who comply with the scholastic requirements. The scholastic year begins on Feb. 1 and closes Oct. 31, there being usually a vacation of one week in May or June. The month of October is devoted to examinations, and practical field instruction is conducted for most of the students during two of the three following months. The length of time required for the different courses of study is as follows: five years for mining engineering, four years for civil engineering, three years for electrical engineering, three years for geographic engineering, two years for topography and hydrography, and one and one-half years for metallurgy. The fifth year in mining engineering is devoted to practical work in the allied mining school at Pachuca and to inspection of mines throughout the republic. For the other courses the diploma is not granted until after one year's practical work in engineering has followed the completion of the scholastic requirements.

The school issues no catalog giving the names of professors, graduates and students. The accompanying table shows, however, the number of students in attendance during the year ending Oct. 31, 1906. These figures indicate that the number annually graduated is small compared with the number that are enrolled during the first year. The total number of graduates since 1792 is 522, an average of less

Courses.	1st Year.	2d Year.	3d Year.	4th Year.	5th Year.	Total.
Civil engineering	88	34	16	6	.	144
Mining engineering.	8	3	1	0	7	19
Geographic eng'g..	2	..	..	..	..	2
Topography and hydrography	11	3	..	..	..	14
Metallurgy	7	7	..	..	..	14
Total	116	47	17	6	7	193

than five per year; since 1896, however, the average number per year has been about fourteen. The word graduate here means those who have obtained the diploma after having completed the required additional year of practice. In 1906 there were 15 graduates, of whom 9 were in civil engineering, 3 in mining engineering, 1 in geographic engineering, 1 in topography and hydrography, and 1 in metallurgy.

The courses in civil and mining engineering have the same program of studies during the first three years. For the first year the subjects are higher mathematics (3), descriptive geometry (3), surveying and hydrography (3), topographic drawing (2), and architectural drawing (2), the numbers in parentheses denoting the number of exercises per week. For the second year the subjects are analytic mechanics (3), stereotomy and structures (3), mathematical physics (3), topographic drawing (2), and architectural drawing (2). For the third year the subjects are applied mechanics (3), hydraulics (3), stresses by analytic and graphic methods (3), strength of materials (3), architectural drawing (2), and machine drawing (2). During the fourth year these courses have in common political economy (2), while the civil engineers take roads and railroads (3), rivers and harbors (3), and exercises in design (4), and the mining engineers take chemical analysis (6), mineralogy and geology (6), and design of machines (4). There is also published a course in industrial engineering, the program of which differs from the above only in some of the subjects of the fourth year;

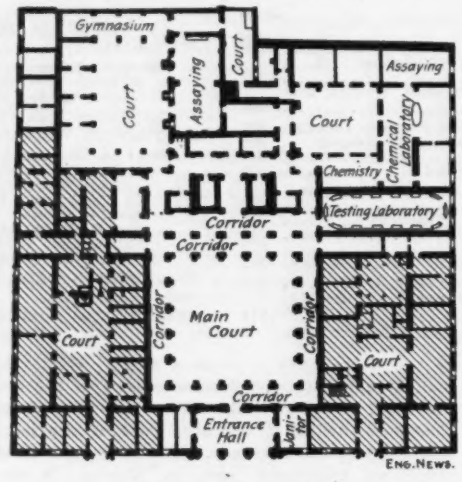

Fig. 2. Lower Floor.

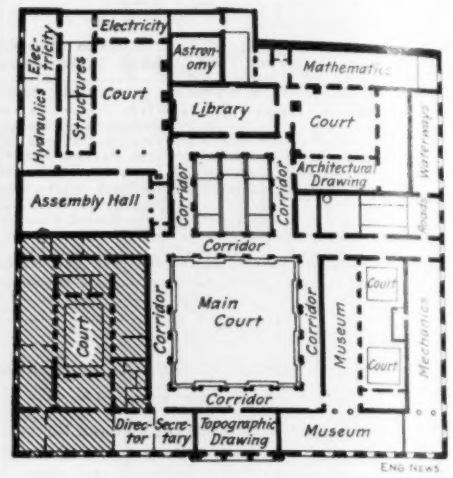

Fig. 3. Upper Floor.

FIGS. 2 AND 3. FLOOR PLANS, NATIONAL ENGINEERING SCHOOL OF MEXICO.

there appear, however, to be no students in this course. The two years' course in topography and hydrography includes mathematics, mechanics, surveying, hydraulics and drawing, while the three years' course in geographic engineering is of a higher grade in that it embraces meteorology, astronomy, geodesy and the method of least squares. The course in electrical engineering has not yet been fully developed, and at present has only one student. There is no division of the year into terms, but instruction in each of the above subjects continues through eight months.

In addition to the above class work there are also given during the school year practical exercises in surveying and in the testing of materials. After the close of the first year, all students who take surveying have field practice for two months. After the close of the second year there is practice in mine surveying for the

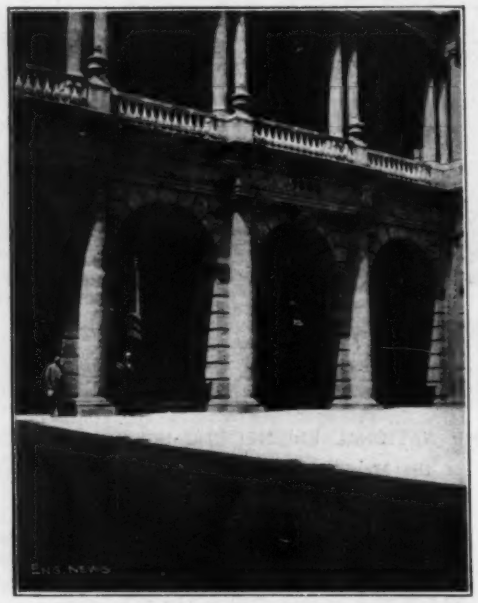

Fig. 4. Main Court, National Engineering School of Mexico.

mining engineers and in geodetic work for the geographical engineers. After the end of the third year there is required two months' practice in mechanical or construction work. It is thus seen that, both throughout the courses and after their completion, the aim of the school is that candidates for a degree shall have been brought into close touch with practical engineering work. A thesis is also required as one of the conditions of graduation.

Returning now to the consideration of the building occupied by the school, it may be noted that it contains two very beautiful rooms. One of these is the assembly hall on the second floor, which has fine columns and statuary along its walls; in this room the formal exercises of welcome to the American Society of Civil Engineers, at its convention of 1907, were held, as also the sessions of that convention. The other is the library room; prior to 1868 this was occupied as a chapel, and there still remain upon its walls fine religious paintings and frescoes. The testing laboratory on the first floor has cases for the exhibition of specimens so arranged as to produce an excellent aesthetic effect, and the same may be said regarding the museum of zoology and paleontology. The recitation and drawing rooms are, however, quite plain, and no maps or photographs of engineering works are upon their walls. The architectural drawing room is a large one, which can accommodate sixty students at one time. Upon the plans in Figs. 2 and 3 are given names indicating the uses of the principal rooms, most of the smaller unnamed rooms in the portion of the building devoted to the school being for storage or for the use of janitors.

The laboratories of the school include one in chemistry, one in mineralogy, and one for the testing of materials, all these being well equipped. The testing laboratory has a French machine of 60,000 kilograms capacity, a Riehlé machine of 10,000 kilograms capacity, an Olsen cement machine, and a Thurston torsion apparatus; around the walls of this room is a large collection of specimens that have been tested. The main museum contains excellent collections of minerals, rocks, and meteorites, and good collections in paleontology and zoology. There are also smaller museums attached to the class rooms, which contain models of mechanical appliances and of engineering structures. The library has 6,430 books and 5,060 pamphlets. These are cataloged in a manuscript volume, while a card index has been begun during the present year. The class work in surveying is done in the central tower, seen in Fig. 1; here is a large collection of field instruments, much larger than seems necessary for the number of students now in attendance, and practice in the use and adjustment of these instruments is carried on throughout the year on the roof of the building. In general, the equipment of the school seems quite satisfactory, except in physics, but plans for a physical laboratory are now under consideration. Weather observations are taken daily on the roof of the building.

The arrangement of the class rooms is quite different from that in the colleges of the United States, owing to the different methods of instruction. The seats of the students are upon opposite sides of the room, while the desk of the professor and a blackboard occupy the two other

sides, the central part of the room being free, so that each student can easily see both the professor and the blackboard. The exercise is in the form of a discussion of the assigned lesson in the text-book, a student standing at the blackboard and explaining the lesson, while the professor asks questions, corrects errors, and supplies additional information. The professor has no text-book at his desk, and students are expected not to consult their books but to closely follow the discussion. Usually only two or three students are called upon for explanations during the exercise, which lasts for an hour and a half.

During the present year there are used in the class work of the school 27 text-books, of which 4 are in the Spanish language, 8 in French, and 15 in English. Although few of the students can speak either French or English, they are able to read the books in these languages with sufficient facility so that, after the class exercise, which is conducted in Spanish, the subject cannot fail to be clearly understood by those who earnestly desire to do so. Of the 15 text-books in English, 3 are published in London and 12 in New York. While formal lectures are seldom given by the professors, the general methods of instruction are more European than American, but the influence of the engineering practice of the United States is decidedly predominant in all lines except in that of drawing. In regard to drawing, it may be noted that the Mexicans are of an artistic temperament, which renders them, after slight training, excellent penmen and draftsmen. This, in connection with the considerable amount of architectural work done by the students of the school, according to the European style, has resulted in drawing which is much neater and more artistic than that of the engineering colleges of the United States. Some of the theses of graduates of this school seen by the writer contain numerous drawings which are of high excellence from both artistic and engineering points of view.

All the expenses of the school are defrayed by the Mexican government, it being a part of the system of public instruction. In 1896 there was expended for its maintenance and operation $72,041, in Mexican money, this including the expenses of the practical instruction given in the fifth year of the mining course at Pachuca. Changes in the program of instruction or in the regulations of the school can only be made after approval by the minister of public instruction, and authorization by the President of the republic. The number of professors is at present 24, who are aided by five assistants. The salaries paid are low, and most of the professors devote only a few hours per week to the work of instruction, they being engineers engaged in private practice who are in the building only at the hours assigned to them for class work. This system cannot produce the best results, since the interest of the professors in the school must necessarily be subordinate to their business practice. The faculty influence, which plays such a prominent part in the development of the engineering colleges of the United States, appears to be largely lacking. Some of the professors remain with the school only two or three years, resigning on account of the growth of their private practice. The work of the school is, however, well systemized, and its records of the attendance and scholarship of the students appear to be very complete and thorough. As one instance, it may be noted that a number is assigned to each student on the roll, the head janitor places a blank upon the desk of each professor at the beginning of each exercise, the professor records upon the blank the numbers that designate absent students, certifies to the same by his signature, and the records of all the exercises of the day are filed in the evening in the office of the secretary.

With respect to the students, the writer failed to notice any peculiarities of dress or manner, such as generally distinguish college students in the United States from other young men. The life of the students seems to be quiet and uneventful, there being no athletic sports and no distractions from fraternities or social clubs. Young men who are in earnest can and do undoubtedly obtain excellent training in engineering, but those who are neglectful or indolent appear not to be pushed and urged as in the United States. Of the number of students entering, it has been shown above that only a small percentage complete a course and obtain a diploma. Of the number enrolled in a given subject about one-half, on the average, are disqualified from entering the examination. For example, in 1906 the number enrolled in descriptive geometry was 76, of whom 27 were admitted to examination; the number enrolled in hydraulics was 42, of whom 34 were admitted to examination. The number of those who pass an examination is about 80% of those admitted, or about 45% of those enrolled.

Notwithstanding that the program of studies of the four-year courses of this school is not comparable in breadth and thoroughness with those in the best engineering colleges of the United States, the above facts clearly show that its standard of instruction is high and that its methods contain many elements of value. Probably its students would be benefited by a partial introduction of the American plan of class recitations, and probably good results would follow if a greater responsibility were put upon its professors. Under the present arrangement there is, however, the advantage that the professors have the advice of graduates who perhaps have themselves been professors and who are eminent in the engineering profession. For instance, Roberto Gayol, the designer of the sewerage system of several Mexican cities, originated the present course in hydraulics and continues to take a deep interest in its work; and Manuel Maroquin, the engineer in charge of the new water-works of Mexico City, has conducted in the testing laboratory of the school during the past year an extensive series of experiments upon concrete columns reinforced with hoops.

Mexico is to be congratulated upon the excellent work of this national engineering school and upon the high professional standing of its graduates.

The officers of the school are a director, an assistant director, a secretary, a treasurer, a librarian, and the professors, all of whom are appointed by the president of the republic. It is required that professors shall be citizens of Mexico and be graduates in courses which cover the subjects they are to teach. The diploma conferring the title of Engineer is issued by the secretary of public instruction after certification by the director that the candidate has satisfactorily complied with all the requirements. This title or degree is an honorable one in Mexico and without the same it is impossible for one to hold a responsible position on work conducted by the government. Graduates of foreign institutions may also obtain this title or degree after satisfactorily passing examinations in the national engineering school.

Luis Salazar, C. E., is the director of the school, and Miguel Alvarado, C. E., is its secretary. To them, to Braulio Martinez, professor of surveying and statics, and to Octavo Bustamante, professor of hydraulics, the writer is under obligation for many courtesies and for kind assistance in collecting the facts that form the basis of this paper.

THE USE OF RAILS 60 FT. LONG for electric interurban railways was noted in our issue of Sept. 12, but their use on railways of this character is much more general than might appear from that note. They are used on the third-rail line of the Aurora, Elgin & Chicago Ry., and on many long-distance trolley lines.

ACETYLENE LAMPS FOR WRECKING CRANES are being tried on the Lake Shore & Michigan Southern Ry. and the Union Pacific Ry., and are reported as being satisfactory in service, even during high winds. The generator is a vertical cylinder 24 × 48 ins., and supplies two enclosed arc lights on the boom, three 9-in. headlights, and the necessary lamps in the cab. The arc lights have 10-in. globes surmounted by 24-in. reflectors, and are connected to the gas pipe lines by flexible hose. The lighting equipment in each case has been furnished by the Davis Acetylene Co., of Elkhart, Ind., which has also supplied similar equipment to steam shovels and dredges.

THE PROPORTIONING OF STEEL RAILWAY BRIDGE MEMBERS.*

By HENRY S. PRICHARD,† M. Am. Soc. C. E.

The proportioning of steel railway bridge members in accordance with the calculated stresses involves many questions concerning which engineers are not in accord. A number of the fundamental questions are discussed in the following, under separate heads.

AVAILABLE STRENGTH OF STRUCTURAL STEEL.

This article is written with special reference to open-hearth steel with a specified ultimate strength of 60,000 lbs. per sq. in., which is the quality at present most favored for bridge members by engineers. The ultimate strength, however, is but a temporary strength, of no use except as an index to the quality and permanent strength. If iron or steel is strained beyond what is commonly known as the elastic limit and allowed to rest, or if, as in Wöhler's famous experiments, part of the load is permanent and part continuously repeated, a permanent strength will be developed in excess of the elastic limit. Launhardt and others founded formulas on the results of Wöhler's experiments, but they should not be applied to the proportioning of bridge members, because at the elastic limit the deformation is so great that before the strength of the steel of which the members are composed could be increased by overstraining, most members would be elongated or compressed and injured to such an extent that they would be incapable of properly performing their functions in the bridge; thereby jeopardizing adjacent members.

As a basis for designing steel bridges, the critical question in regard to strength is: What is the greatest permanent or indefinitely repeated load which structural steel will sustain without undue deformation? What is commonly known as the elastic limit occurs in tests of full-size eyebars at about 55%, or over, of the ultimate tensile strength, and in specimen tests at about 60% or over. At the elastic limit (or yield-point) there is a great and sudden loss in elasticity, causing a decided flow; but there is some loss before (and sometimes long before) this limit is reached. These slight imperfections in elasticity are caused by internal stresses, and occur only on the first application of the load. Bauschinger and others have shown that after an initial stress of a given magnitude within the elastic limit has been once developed, the material is afterwards perfectly elastic up to the limit of that stress.‡ Bauschinger's experiments on the steel known as "ingot iron," with an ultimate strength of 62,000 lbs., showed a permanent strength under indefinitely repeated stresses of about 34,000 lbs.,§ which is 55% of the ultimate tensile strength. From this fact and the previously stated fact that the yield-point in tests of full-size eyebars occurs at about 55% of the ultimate, it would appear that the strength indicated by this percentage is the answer to the critical question with which this paragraph begins; in other words, the greatest available strength of structural steel in tension is about 55% of its ultimate tensile strength. As the yield-points in tension and compression occur at about the same intensity of load, it seems reasonab'e to assume that the greatest available strength of structural steel in compression also is about 55% of its ultimate tensile strength.

Bauschinger's experiments on metals under alternate stresses show that the steel termed "ingot iron" has a strength of about 45%, and wrought iron about 50%, of the ordinary ultimate strength; while Wöhler's experiments on wrought iron show only 30%. This discrepancy suggests some difference (possibly as regards internal stresses) in the condition of the specimens tested.

Some tests on a steel bar at the Watertown Arsenal showed that "a permanent deformation of one-half of one percent. in either tension or

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*After a paper by the author published in the Proceedings of the Engineers' Society of Western Pennsylvania for July, 1907.

†Statistician, American Bridge Co., Frick Bldg., Pittsburg, Pa.

‡Trans. Am. Soc. C. E., Vol. XLI., p. 236.

§Trans. American Soc. C. E., Vol. XLI., p. 178.

compression entirely destroyed the perfect elasticity of the material under the opposite kind of stress."* That this loss of elasticity is only temporary was shown by high elastic limits in both tension and compression in tests at the Watertown Arsenal of specimens cut from an overstrained steel bar after a rest of three years and three months.† A similar result followed a rest of one month and seven days.‡ From this it appears that when long intervals of rest occur the strength is not impaired by occasional alternating stresses.

SAFE WORKING STRESSES.

To allow for defects, deterioration and contingencies, a factor or margin of safety is necessary in designing bridges.

Owing partly to defects in the assumptions from which the stresses are calculated, partly to the different percentages of stress increase which an increase in live load will cause, and partly to variation in liability to defects, deterioration or contingencies, some members of a bridge will need a greater margin of safety than others. For this reason the margin of safety should be in part general and in part specific. The simplest method of making general provision for safety is to use unit stresses in designing which have the desired factor with regard to the greatest available strength of structural steel, while the simplest method of making specific provision is to use these same unit stresses, but to make such additions to the stresses in the different members as will give the security desired, and in some cases to require certain details of design, quality of steel, or method of manufacture.

As the line between reasonable safety and unsafety is not sharply marked, but has to be fixed somewhat arbitrarily, and as it is wise in designing a new bridge to provide for future possibilities which would not have to be considered in determining the present safety of an existing bridge, it is entirely reasonable for engineers to provide a greater margin of safely in designing a new bridge than they require as a condition of safety in an existing one.

Manufacturers require the privilege of such variation in quality that steel with an ultimate strength of 55,000 lbs. is liable to be furnished when 60,000 lbs. is specified. The available strength should, therefore, be taken as 55% of 55,000 lbs., or about 30,000 lbs. per sq. in. The frequency with which, under the trying conditions of ever-increasing loads, the calculated stresses, with addition for dynamic effect, have equaled or come near to 30,000 lbs. per sq. in., justifies the allowance of high unit stresses in existing structures before they are condemned. Few bridge engineers, after making proper allowance for dynamic effect, would in actual practice condemn a structural steel bridge, in good condition, simply on account of calculated tensile stresses of 20,000 lbs. per sq. in., and it may be considered that good practice permits this stress in existing steel bridges.

The tensile stress used in designing new bridges should be much less than permitted in existing ones; say, 20% less, that is, 16,000 lbs. per sq. in.

The greatest load per square inch of gross section allowed on compression members should be somewhat less than the allowed stress per square inch of net section in tension members, as it is doubtful whether the rivet shanks, considered as sectional area, have the same efficiency as the metal they replace.

The fact already noted that Wöhler's experiments on wrought iron under alternate stresses indicate less strength (in proportion to ultimate) than Bauschinger's, suggests that in some circumstances steel may have less strength to resist alternating stress than Bauschinger's experiments would show. To be on the side of safety, therefore, the allowance for alternate stresses should be based on Wöhler's experiments on wrought iron, instead of Bauschinger's experiments on steel. This will provide sectional areas greater than required for stresses in one direction only, in the proportion of 55 to 36, which is an increase of 50%. This applies directly to members with riveted end connections.

In members with pin ends, owing to the play in the pin holes the loads which produce alternate stresses are applied with an impact which not only increases the stress, but tends to enlarge the pin holes. Pin-connected members liable to frequent alternations of stress had best be avoided, but if used they should have greater area than required for similar members with riveted end connections.

Maximum wind stresses occur so seldom in the lifetime of a bridge, and the intervals between maximum stresses are so great, that it is not necessary to add anything to the area required by the stress in either direction, on account of wind stresses in an opposite direction.

The foregoing conclusions lead to specific recommendations, as follows:

Safe working stresses for tension in main members, 16,000 lbs. per sq. in.

Safe loads on compression members, 15,000 lbs. per sq. in. properly reduced for length.

Members liable to alternate stresses should be proportioned for each kind of stress separately considered; but each kind of stress should be regarded as increased by F percent. of the lesser kind, not including any increase on account of alternate stress from wind. When a member has riveted end connections, F should be 50; when it has pin ends, F should be 100.

PROVISION FOR POSSIBLE INCREASE IN LIVE LOADS.

Under the caption "Safe Working Stresses," it has been shown that the unit stresses used in designing a new steel bridge should have a considerable factor of safety as compared with the "available strength of structural steel," and that they should be less than the stresses permitted in an existing bridge; say, 16,000 lbs. per sq. in. in tension and 15,000 lbs., properly reduced for length, in compression, as previously suggested. With due care, suitable allowance for impact and well-designed details, the use of these unit stresses in proportioning will insure a reasonable and fairly consistent margin of safety in all bridge members, for defects and deterioration. At first thought it might seem that this would likewise be sufficient to secure consistent and reasonably safe provision for considerable increase in load. That this is not the case is shown by conceiving an increase of 25% in the live-load stresses of four hypothetical members so proportioned that the dead-load stresses combined with the stresses from the specified live load produce tensile unit-stresses of 16,000 lbs. per sq. in., as follows:

TENSION MEMBERS.

	1st Eyebars.	2d Eyebars.	3d Counters.	4th Eyebars.
Live and Impact	+ 192,000	+ 192,000	+ 192,000	±184,000
Dead	0	+ 192,000	—160,000	+ 192,000
Maximum	+ 192,000	+ 384,000	+ 32,000	+ 376,000
Unit-stress	+ 16,000	+ 16,000	+ 16,000	+ 16,000
Area, sq. ins....	12.0	24.0	2.0	23.5
25% increase in live and impact	+ 48,000	+ 48,000	+ 48,000	± 46,000
Unit-stress	+ 20,000	+ 18,000	+ 40,000	+ 18,000
				— 1,600

The third and fourth cases show that an increase of only 25% in the live load may produce very high unit-stresses in counters and considerable compression in members built to resist tension only, unless special provision is made for such a contingency. In other members not liable to counter stresses, nearly double the specified live load will not result in calculated stresses in excess of the yield point. As it does not require the addition of much metal to counters and members liable to counter stresses, to give them as well as other members of a bridge a factor of two as regards extraordinary loads, it seems wise to do so.

The first and second cases show that the proportioning is not economical as regards an increase in loading, as the intensity of the stress under the increase is greater in the first case than in the second. In the light of experience, to secure fairly long life, it is wise to proportion bridges with special reference to some future increase in loading. Twenty-five years ago the assumption of 100% increase would have been none too large. At present, as the loads have seemingly approached fairly close to the limitations imposed by clearances between the tracks and above the roadbed, the assumption of 50% for increase in normal loading is probably ample.

A bridge would be most economically proportioned for a 50% increase in the live load, if the said live load, so increased, with suitable additions for impact, and in combination with the dead load, produced in all the members the greatest unit stresses allowed in existing structures, say, unit stresses corresponding to 20,000 lbs. per sq. in. in tension. In other words, if in course of time a bridge had to be condemned in consequence of an increase of slightly over 50% in the live load, it would have no weakest part, like the deacon's famous "one-horse shay," but would be equally unsafe in all its members.

From the foregoing it would appear that to provide a reasonable and, as nearly as may be, consistent margin of safety in all directions, it is necessary to design each member for the most severe of three separate assumptions; first, for the specified live load, on the basis of 16,000 lbs. tension; second, for the contingency of extraordinary live loads 100% greater than specified, on the basis of 32,000 lbs. tension; third, for possible future normal live loads 50% greater than specified, on the basis of 20,000 lbs. tension.

The determination of stresses on three different assumptions is cumbersome, and the use of three sets of unit-stresses is complicated and otherwise objectionable. Precisely the same result can be accomplished, using only the specified unit-stresses, by making proper additions to the stresses to provide for possible increase in live load. The amounts to be added can be determined as follows:

Let D = the dead load stress.
" L = the static stress from the specific live load.
" I = the addition for dynamic effect of the specified live load; or briefly, impact.
" P = the amount to be added to the live load stresses and impact to provide for possible increase in loading.

When live and dead load stresses are of the same kind—

$$\frac{L+I+D+P}{16{,}000} = \frac{1\frac{1}{2}L+1\frac{1}{2}I+D}{20{,}000}$$

$$P = \frac{L+I-D}{5} \quad \ldots\ldots\ldots\ldots (1).$$

When the live and dead load stresses are of opposite kinds—

$$\frac{L+I-D+P}{16{,}000} = \frac{1\frac{1}{2}L+1\frac{1}{2}I-D}{20{,}000} \text{ or } \frac{2L+2I-D}{32{,}000}$$

$$P = \frac{L+I+D}{5} \text{ or } \frac{D}{2}, \left\{\begin{array}{l}\text{whichever gives}\\ \text{the larger result}\end{array}\right\} \ldots\ldots (2).$$

Whatever may be the necessity for provision for increase in loading under present conditions, there is little doubt that had it been made twenty or twenty-five years ago, it would have prolonged the life of many a bridge.

PROVISION FOR DYNAMIC EFFECT OF THE LIVE LOAD.

The experiments of Prof. Robinson* and Prof. Turneaure† have shown that the maximum dynamic effect of the live load in trusses of spans over 100 ft. is due to accumulative vibration. The greatest accumulative vibration, in the experiments referred to, occurred when the load consisted of cars about twice as long as the panels, moving at a speed which made the dynamic impulses harmonize with the period of vibration of the trusses. Accumulative vibration of considerable magnitude also occurred under engine loads when the circumference of the driving wheels was about equal to the panel length and the period of revolution of the drivers harmonized with the period of vibration.

The greatest single dynamic impulse under normal conditions is due to the increased pressure which momentarily results from the action of centrifugal force on rapidly revolving imperfectly balanced locomotive driving wheels. The percentage

*Johnson's "Materials of Construction," p. 522.
†Johnson's "Materials of Construction," p. 512.
‡Watertown Arsenal Report, 1886, Part 2, pp. 1589-95.

*"Vibration in Bridges."—Trans. Am. Soc. C. E., Vol. xvi. (1887).
†"Some Experiments on Bridges under Moving Loads."—Trans. Am. Soc. C. E., Vol. xlii. (1899).

of increase in pressure as compared with the weight on the drivers was computed by Prof. Turneaure for certain locomotives, for speeds of forty and fifty miles per hour, and by the writer for higher speeds. Excluding freight engines, the percentages of increase are as follows:

At	40	miles	per hour,	12 to 13%.
"	50	"	"	19 to 21%.
"	60	"	"	27 to 30%.
"	70	"	"	37 to 40%.
"	80	"	"	48 to 53%.
"	90	"	"	61 to 67%.
"	100	"	"	75 to 83%.

In stringers and short plate girder and beam spans, the greatest dynamic effect is produced during a single revolution of the locomotive driving wheels. It results from a combination of the centrifugal pressure of the imperfectly balanced driving wheels with the increase or decrease in pressure, as compared with a static load, induced by the rapidity with which the load is applied.

The modifying influence of rapidity of application would be a decrease only for very high speeds over very short shallow girders; it is not inconceivable that such an effect might at times occur in practice. On occasion 100-lb. rails would probably carry a heavy passenger engine over an 8-ft. gap with less strain if the engine were moving very rapidly than if it were moving very slowly, especially if the imperfectly balanced driving wheels were in such a position that the centrifugal force acted upward. A single driving wheel with a load of 30,000 lbs. at the center of a standard 100-lb. rail of high elastic limit, simply resting on two supports 8 ft. apart, would produce an extreme fiber stress of 49,300 lbs. per sq. in. and a deflection of 0.435 in.; while if traveling at 100 mi. per hr., in going from the end to the center it could only fall 0.144 in. even if unrestrained. Not till it passed the third quarter point could it produce as much deflection and stress as a similarly situated static load, and it is hardly likely that the extreme fiber stress could be more then 37,000 lbs. per sq. in.

It is more important, however, to know the *increase* which may result from the rapid application of the load. The problem is a very complicated one and has not been solved by analysis. Among the experiments made for the British Board in 1848 by James, Willis and Galton was a series on a wrought iron beam 9 ft. long, 1 in. wide and 3 ins. deep, which was subjected to a load of 1,778 lbs. moving at different velocities, with results as follows:

Velocity, in ft. per sec.....	0	15	29	36	43
Deflection, in ins.....0.29	0.38	0.50	0.62	0.46	

In this series of experiments the speed causing the greatest deflection was 36 ft. per sec. As the deflection of 0.29 in. corresponds to an extreme fiber stress of 32,000 lbs., the stress in all the tests was in excess of the elastic limit and is not, therefore, proportional to the deflection. Comparing the deflections with those of other iron beams strained beyond the elastic limit, it seems likely that the maximum dynamic effect, on the beam in question, was about equal to the effect of a 60% increase in the load statically considered.

As the speed necessary to produce the maximum dynamic effect increases with the span and depth, it is only very short bridges, say something under 25 ft., that are liable to the maximum increase from the rapid application of the engine load.

There is a popular belief that dead load is highly beneficial in reducing the effect of impact, a belief which is supposed by many engineers to have a firm theoretical basis. To test whether there is any warrant in theory for such a belief, the impact was determined in a number of simple cases by a formula which is theoretically accurate within the elastic limit and which can be readily derived from those developed in Art. 112 of Prof. Merriman's "Mechanics of Materials."

Let a load P fall from a height h to the center of the top of a beam of uniform section resting on two supports. Let W be the weight of the beam, B the uniformly distributed dead load carried in addition to its own weight, Δ the deflection due to a static load P, and I the static load equivalent in effect to the impact.

$$\text{Then } I = P\sqrt{\frac{2h}{\Delta\left(1+\frac{17(W+B)}{35P}\right)}+1} \quad \ldots\ldots (3)$$

For $h = 0$, this formula reduces to $I = P$, irrespective of the amount of dead load.

In each of the specific cases for which the impact was determined, a load of one ton was assumed as falling from a point ½-in. above the center of a rectangular steel beam 6 ins. deep resting on two supports 12 ft. apart. The thickness of beam and consequently its own weight, the weight of the uniformly distributed dead load carried, and the impact, or rather its static equivalent in effect, were as follows:

Beam—Size, Inches.	Beam—Weight, Tons.	Dead Weight Carried, Tons.	Total Dead Weight, Tons.	Impact, Tons.
6 x 2	0.25	0	0.25	2.95
6 x 4	0.50	0	0.50	3.86
6 x 8	1.00	0	1.00	4.93
6 x 2	0.25	0.25	0.50	2.82
6 x 2	0.25	0.75	1.00	2.61
6 x 2.2	0.27	0.75	1.02	2.72

The foregoing examples show that dead load is of very little theoretical advantage in decreasing impact. Theoretical conclusions should, however, be accepted with caution, as a lack of elasticity in either the falling load or the dead load carried by the beam will result in dissipating a part, and in some cases a large part, of the energy assumed by theory to be spent in straining the beam.

Dead load, by holding the members to a good bearing, is indirectly beneficial in preventing some of the impact which might otherwise result from the rapid application of the live load to a bridge with loose joints. There is a further indirect benefit from dead load in the fact that it increases the total stress and thus makes the stress from dynamic effect a smaller proportion of the total.

Besides the Robinson and Turneaure experiments previously referred to, extensive experiments to determine the dynamic effect of the live load have been made on Baltimore and Ohio R. R. bridges by a committee of the American Railway Engineering and Maintenance of Way Association, an account of which is given in the Proceedings of their annual convention, 1905. The records of these tests were lost in the Baltimore fire, but a summary of the results was saved.

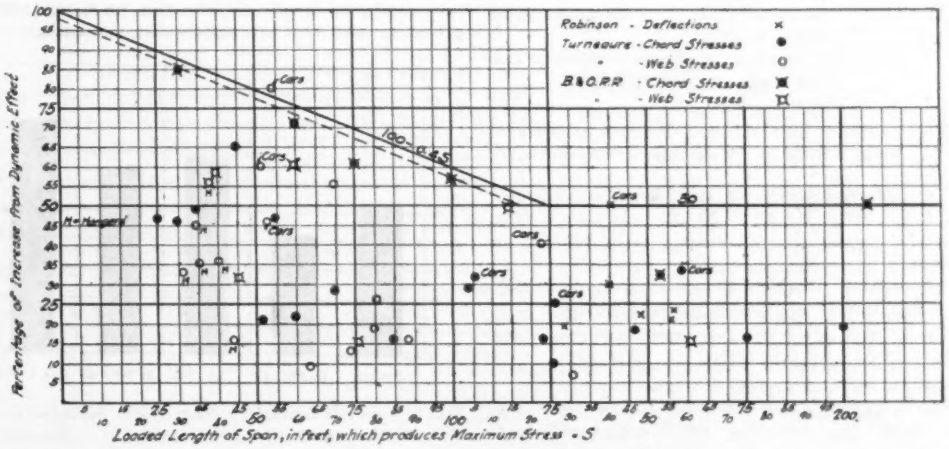
From the reports of all the tests referred to, the cases giving the maximum percentage of increase in the chords and webs were selected and plotted in the diagram shown herewith, omitting from consideration those recorded results after which Prof. Turneaure has placed an interrogation.

In the Baltimore and Ohio experiments, the speed of the trains ranged from 40 to 70 mi. per hr., while in Robinson's experiments the greatest speed was 47 mi. per hr. and in Turneaure's experiments 52 mi. per hr.

One observation plotted at loaded length 55 ft., records an increase of 80% in the stress in the center diagonal of bridge No. 16 of Prof. Turneaure's experiments, which occurred when the bridge was loaded from end to end (127 ft.) with cars, which produced a total stress, including dynamic effect, of only 900 lbs. per sq. in. This increase is no criterion as to the increase from dynamic effect to which the member is liable when the bridge is so loaded as to produce the maximum stress therein. All the other observations lie in a field closely bounded by two straight lines intersecting at a point indicated by percentage 50 and loaded length 117. The sudden change at this point in the direction of the boundary line is probably due to the fact that for short loaded lengths the chief causes of dynamic effect are the centrifugal pressure from the partly unbalanced locomotive driving wheels and the rapidity and impact with which the loads are applied, while for long lengths the chief cause is accumulative vibration.

The diagram indicates that percentages varying as a straight line from 100 at loaded length zero to 50 at loaded length 125, and a percentage of 50 beyond that length, will cover the amount which should be added to the live load for dynamic effect.

It seems hardly likely that the effect of accumulative vibration will be as great in the webs as in the chords, but the writer would not recommend any reduction on that account in designing bridges.


Robinson - Deflections
Turneaure - Chord Stresses
- Web Stresses
B&O.R.R - Chord Stresses
- Web Stresses
Cars
H=Hangers
Percentage of Increase from Dynamic Effect
Loaded Length of Span, in feet, which produces Maximum Stress - S

MAXIMUM DYNAMIC INCREASE OF STRESS FOUND IN VARIOUS SETS OF TESTS ON RAILWAY BRIDGES UNDER MOVING TRAINS.

The observations only extend to 207 ft., but accumulative vibration occurs in spans of much greater length and in one respect is liable to be more severe than on shorter spans as cars are the chief factor in producing accumulative vibration and cars are a greater factor in producing the maximum stresses in long spans than in short ones. On the other hand the impulses, the recurrence of which occasions the accumulative vibration, are lighter in comparison with the weight of the bridge for long spans than for short ones. Further, even if the same percentage of increase from dynamic effect occurred in a long span as in a short one, it would be a smaller percentage of the entire stress and therefore less dangerous. Further, for very long spans a cantilever type is usually used and the cantilevers would not be apt to vibrate harmoniously with the suspended trusses. From a consideration of these arguments pro and con it seems best to continue a 50% addition for dynamic effect up to say a span of 500 ft. and to then gradually lessen the percentage till it reduces to zero at 1,000 ft.

All of the foregoing conclusions refer to single track bridges. The liability to conditions which will produce great dynamic effect on more than one track at a time is quite remote, especially on very long spans. Should such conditions occur, the general provision for safety, the provision for possible increase in loading, and provision for dynamic effect from the load on one track would doubtless be sufficient without any provision for dynamic effect from loads on other tracks, except for spans less than 125 ft., for

which some, though not full, addition should be made for simultaneous impact from loads on more than one track.

For very long spans the liability to a full load on all tracks and full dynamic effect on even one track, is so remote that it is not necessary to make full provision for the dynamic effect of the load on even one track.

When trusses are liable to stresses from loads on more than one track, the maximum dynamic effect from the load on any one track as compared with 1.0, the possible dynamic effect from loads on all tracks, is about as follows:

For a symmetrical two-truss double-track bridge... 0.7
For the intermediate truss of a three-track bridge.. 0.58
For a symmetrical two-truss three-track bridge.... 0.47
For the middle truss of a four-track bridge..... 0.42
For a symmetrical two-truss four-track bridge..... 0.35

A simple rule which will approximately meet all the requirements of the case is to deduct ten for each additional track, from the percentage of increase indicated for the dynamic effect of the live load on a single track bridge.

The conclusions to which this analysis of the dynamic effect of the live load has led can be formulated as follows:

Let L = the static stress, moment or shear, from live load.
" S = the length in feet of the loaded portion of the span.
" N = the number of loaded tracks causing the maximum stress, moment or shear.
" U = the percentage of increase from dynamic effect.
" I = the addition for dynamic effect of the live load; or briefly, Impact.
" $I = UL/100$.

The provision for the dynamic effect of the live load should be made by adding percentages as follows:

For a loaded length of span less than 125 ft.,
$$U = (100 - 0.4\ S) - 10\ (N - 1) \quad \ldots\ldots (4)$$

For a loaded length of span from 125 ft. to 500 ft.,
$$U = 50 - 10\ (N - 1) \quad \ldots\ldots (5)$$

For a loaded length of span over 500 ft.,
$$U = (100 - 0.1\ S) - 10\ (N - 1) \quad \ldots\ldots (6)$$

The percentages for various loaded lengths are given in the accompanying Table I.

The greatest speed observed during the tests on which the foregoing rules are based was about 70 mi. per hr. Greater speeds occasionally occur on some roads, and may become frequent on many roads, and such greater speeds carry with them the liability to greater impact on short spans. Inasmuch, however, as the provision for possible increase in live load, plus the provision for impact, herein recommended, makes a greater addition to the static stresses in the floor system and light web members than is customary, and inasmuch as greater speed and greater load may not both occur, it was not deemed advisable to make a general recommendation for a further increase over current practice. In special cases, however, it may be advisable to increase the provision for impact on short spans.

The dynamic effect of the live load at train speeds less than 20 mi. per hr. was found to be very small in the Robinson, Turneaure and Baltimore & Ohio experiments, which confirms the wisdom of the usual practice of running slowly over bridges known or believed to be unsafe. Orders for slow speed, apart from the inconvenience they cause, are not a satisfactory remedy for weak or overloaded bridges, as there is some danger that the orders will not always be heeded, but they are a precaution which, with care, may prolong the life of an old bridge.

TABLE I.
Percentages of Increase from the Dynamic Effect of the Live Load.

S Loaded Length of Span.	Percentages of Increase. No. Loaded Tracks 1	2	3	4	S Loaded Length of Span.	Percentages of Increase. No. Loaded Tracks 1	2	3	4
0	100	90	80	70	520	48	38	28	18
5	98	88	78	68	540	46	36	26	16
10	96	86	76	66	560	44	34	24	14
15	94	84	74	64	580	42	32	22	12
20	92	82	72	62	600	40	30	20	10
25	90	80	70	60	620	38	28	18	8
30	88	78	68	58	640	36	26	16	6
35	86	76	66	56	660	34	24	14	4
40	84	74	64	54	680	32	22	12	2
45	82	72	62	52	700	30	20	10	0
50	80	70	60	50	720	28	18	8	0
55	78	68	58	48	740	26	16	6	0
60	76	66	56	46	760	24	14	4	0
65	74	64	54	44	780	22	12	2	0
70	72	62	52	42	800	20	10	0	0
75	70	60	50	40	820	18	8	0	0
80	68	58	48	38	840	16	6	0	0
85	66	56	46	36	860	14	4	0	0
90	64	54	44	34	880	12	2	0	0
95	62	52	42	32	900	10	0	0	0
100	60	50	40	30	920	8	0	0	0
105	58	48	38	28	940	6	0	0	0
110	56	46	36	26	960	4	0	0	0
115	54	44	34	24	980	2	0	0	0
120	52	42	32	22	1000	0	0	0	0
125 to 500	50	40	30	20					

EVAPORATION LOSSES IN IRRIGATION.

By SAMUEL FORTIER,* M. Can. Soc. C. E., D. Sc.

One can perhaps form a better idea of the amount of water which is annually diverted from western streams for irrigation purposes by remembering that it would cover the six New England states 12 ins. deep. The cost of this water to the farmers of the irrigated districts of the western states and territories is in round numbers $50,000,000 a year. This includes the yearly charge for irrigation water and the labor and equipment required in conducting it to the fields and in spreading it over the surface.

When one considers the high value of the products raised by means of irrigation he is not surprised to find that a considerable percentage of the gross revenues is used to pay for water. Of the two essential elements in crop production, soil and water, the latter often possesses the greater value. Under the Twin Falls state irrigation project in Idaho sage brush land with a water right sells for $25.50 per acre, but the water right is estimated at $25, while the land is placed at only 50 cts. per acre. In southern California good land without water can be purchased at figures ranging from $5 to $50 an acre. The same quality of land similarly situated is worth from $150 to $400 an acre when provided with an adequate water supply, and when it is made to produce citrus fruits successfully its value frequently exceeds $1,000 an acre.

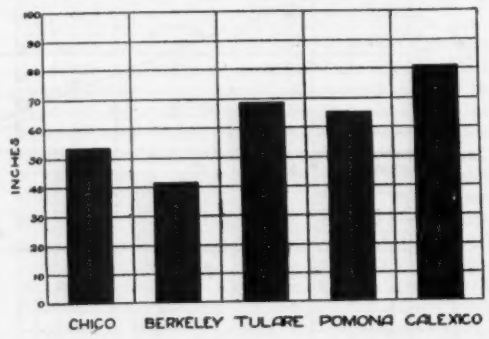


Fig. 1. Annual Evaporation from Water Surfaces at Five Stations in the Irrigated District of California.

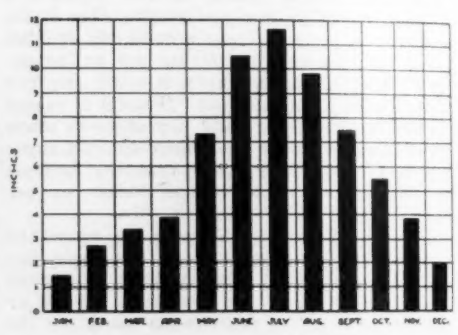


Fig. 2. Average Monthly Evaporation from Water Surface at Tulare, Cal.

Since water has so high a value in the arid region it is a matter of some surprise to learn that so much is wasted. It is still more surprising to learn that western farmers keep on paying from year to year their $50,000,000 for water with little complaining when only about one-third is utilized in a beneficial way. One reason for this is that but few water users know how much of their water supply is wasted and all realize that a part of this loss cannot be prevented.

It was not until after Congress had made appropriations for the investigation of the use of water in the arid region that much was known concerning the volumes carried by irrigation canals, the losses sustained in transmitting these volumes from the channels of streams to cultivated fields and the waste occasioned in an attempt to spread the water thus furnished over the surface of the ground. These investigations have been conducted for nearly ten years by the U. S. Office of Experiment Stations with the use of annual appropriations by Congress. These appropriations were at first small, but they have been gradually increased. Western states have also appropriated funds for the same purpose, to be expended in conjunction with Government funds, and western agricultural experiment stations have likewise cooperated in the same work.

It is generally conceded that the results of these investigations in irrigation, as well as drainage, have been of great benefit to the people of the West. Not the least of these benefits has been a more economical use of water. Scores of canal companies possessing no knowledge of the percentage of water lost by seepage through porous channels have taken advantage of the data furnished them by adopting measures to lessen this waste. In one case this loss was reduced from 30 to 2% in a main canal by proper lining. The introduction of better facilities for the measurement and division of water has also effected a saving. Prior to 1903 the Sunnyside Canal in the State of Washington furnished water for 25,000 acres. A complete system of weirs was installed and each man's share was measured. It was then found that this canal, carrying practically the same volume of water, could supply 38,000 acres. Unless the quantities of water diverted for irrigation are determined by state or national agencies the irrigators as a rule have seldom any true conception of their magnitude. In 1904, the Modesto Irrigation District, of central California, diverted enough water from the Tuolumne River to have covered the irrigated lands to a depth of 15 ft. When this excessive waste of water was pointed out a more economical use speedily followed, resulting not only in a saving of water but in the prevention of water-logging the soil.

Notwithstanding the enormous waste of water in the irrigated districts of the West caused by porous ditches, undefined rights, faulty distribution and careless use, yet all these combined probably do not equal that lost by evaporation. By evaporation losses in irrigation we mean the amount of water which escapes from the surface of water and from cultivated soil, and not that which is absorbed by the roots of plants, drawn up through their tissues and evaporated by their foliage. That part of irrigation water which passes directly from soil or water surfaces into the air in the form of vapor is as truly wasted as if it had been dipped out of the feed ditch by a bucket and carted to another basin.

In considering the losses due to evaporation the question naturally arises: Can they be checked, and, if so, to what extent? It was with a view to finding an answer to questions like this that studies were begun several years ago in California. The State contributed one-half the expense and the United States the other half. It was thought that the conditions which prevail in California would be favorable for such a study. Little rain falls during the summer months, evaporation is excessive in the interior valleys, and irrigation water not only possesses a high value but is, perhaps, more skillfully applied than in any other state of the Union.

The results of these investigations have been summarized in Bulletin 177, recently published by the Office of Experiment Stations of the U. S. Department of Agriculture, and the main object

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of this article is to discuss somewhat more fully certain features of the investigations which properly belong to agricultural engineering.

EVAPORATION FROM THE SURFACE OF WATER.

From the viewpoint of irrigated agriculture the loss by evaporation from the surface of water is of less importance than that from the surface of cultivated soil. It was, however, thought best to adopt some standard to which all measurements might be referred, and for this purpose water was chosen instead of soil, the former being less subject to extreme fluctuations. Then, again, considerable quantities of water intended for the irrigation of land passes off into the atmosphere from storage reservoirs, water channels and flooded fields. It was deemed advisable to determine, if possible, these losses.

Galvanized iron tanks, 2 to 3 ft. in diameter and 30 to 36 ins. deep, were placed in the earth and filled with water. The weekly loss was determined by a hook-gage before refilling. In locating the evaporation stations an effort was made to have them represent the chief irrigation districts of the state. It was thought that the Calexico station, located near the Mexican boundary line in San Diego County, would represent the Imperial Valley; Pomona and Riverside stations, southern California; Tulare station, the San Joaquin Valley; Berkeley station, the cooler coast counties with their greater rainfall; and Chico station, the floor of the large Sacramento Valley. The average evaporation at these points for periods ranging from two to three years is shown in Fig. 1.

The dry, warm summers in California, particularly in the valleys lying between the Coast and Sierra ranges, cause an excessive evaporation in mid-summer. This is shown by Fig. 2, which gives the average monthly evaporation at Tulare, located some 40 miles south of the center of the San Joaquin Valley. There is likewise a wide fluctuation in the weekly rates of evaporation. At Tulare, for example, in mid-summer the greatest loss per week was 3¼ ins., while in mid-winter, during periods of fogs and low temperature (26° to 40° F.), there was little, if any, loss. The maximum weekly rates for the five stations weres 2.8 ins. for Chico; 1.55 for Berkeley; 3.25 for Tulare; 3 for Pomona, and 3.75 ins. for Calexico.

INFLUENCE OF TEMPERATURE ON EVAPORATION.

The temperature of the water used in irrigation varies greatly. Canal water diverted from Sierra streams is not infrequently as low as 50° F., while in the Imperial Valley it has been known to rise above 90° F. Quite often the cold water of the upper portion of a canal system is warm when it reaches the checks of the irrigated fields. In traversing a distance of 30 miles, the temperature may rise from 50° to 80°. This does not mean a rise of temperature on the surface of water in a state of rest, for owing to the continual agitation to which the water is subjected the temperature of the whole mass is raised.

This brings up the question of the influence of temperature on evaporation; or, to state it concretely, if the water used to irrigate one check is at a temperature of 60° F., and that used to irrigate another at a temperature of 80° F., what difference will it make in the loss caused by evaporation, other conditions being the same?

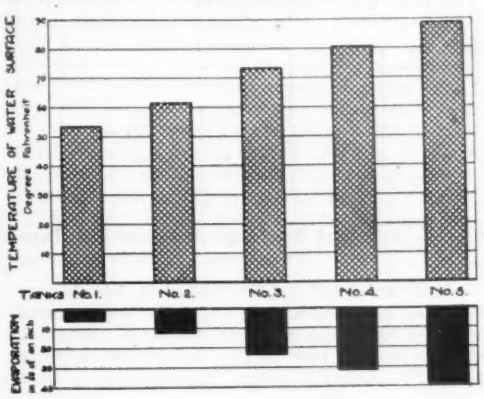


Fig. 3. Influence of Temperature on Evaporation.

In the summer of 1904 a test was made in a field at Berkeley to determine if possible the effect of temperature on evaporation. Five galvanized iron tanks, 22 ins. in diameter and 28 ins. deep, were sunk into the ground. Ice water jackets were placed around two of the tanks and kerosene lamps of different sizes were placed under two. For a period of 30 days, from July 20 to Aug. 20, readings of temperature were taken at 3, 6, 7, 9 and 11 a. m., and at 1, 3, 5, 9 and 12 p. m. At the same time measurements of the amount of evaporation were made with a hook gage reading to 1-64-in. A thermograph kept a continuous record of air temperatures, and water temperatures were read by means of a small detached thermometer. In 1905 similar experiments were made at Tulare, Chico and Lone Pine. The average results of all four experiments are graphically represented in Fig. 3. The tanks at Berkeley and Tulare are shown by Figs. 4 and 5. Analytically, the same results show that an increase of 10° F. will increase the evaporation 1 in. per week.

EFFECT OF SHADE AND SHELTER ON EVAPORATION.

On cropped soils in sunshiny weather part of the soil is in the shade and the remainder in the sun. This is particularly true of bearing orchards. The effect of shade in decreasing the evaporation from mature orchards may be deduced from the temperature records. The diagram shown in Fig. 6 represents temperature records of dry soil in the sun and of dry soil in the shade in an orange orchard near Riverside, Cal. The average difference for a period of ten days was nearly 36° F. In view of the great influence which temperature exerts on evaporation one can form a fairly correct opinion in this indirect way of the effect of shade in decreasing the evaporation during the hours of strong sunshine.

The effect produced by shelter was determined at Berkeley by surrounding two tanks with a tight board fence, 7 ft. high, in the form of a triangle. The effect of this enclosure was to increase the temperature of the enclosed tanks 2.8° F. above that of the two exposed tanks. Making allowance for the increased evaporation due to this raise of temperature the evaporation from the exposed tanks averaged ¾-in. per week more than that from the sheltered tanks. The average wind movement, as determined by a standard anemometer set 18 ins. above the ground and connected with an electric recording instrument, was 2.87 mi. per hr. The average increase in daily evaporation was thus about 1⅛% for each mile of wind movement.

INFLUENCE OF ALTITUDE ON EVAPORATION.

During the summer of 1905, Mr. Frank Adams, of the Office of Experiment Stations, made a limited number of observations on the eastern slope of Mount Whitney, Cal., to determine the effect of altitude on the evaporation from a water surface. Temporary stations were established at the following points on the slope:

Station.	Elevation in feet.
Soldiers' Camp	4,515
Junction South Fork and Lone Pine Creek	7,125
Hunters' Camp	8,370
Lone Pine Lake	10,000
Mexican Camp	12,000
Summit Mount Whitney	14,502

The equipment at each station consisted of an evaporation tank, rain gage, maximum and minimum thermometer, small hook-gage, sling psychrometer and a standard pocket thermometer. Figs. 7 and 8 show the Soldiers' Camp and Mount Whitney stations, respectively.

The results of this investigation, briefly stated, indicated a consistent and steady decrease in the evaporation of a 20-day period from the lower to the higher elevations. This is clearly shown by the accompanying diagram, Fig. 9. The curve was made to pass underneath the small circle which marks the weekly evaporation on the summit of Mount Whitney, for the reason that the exposed position increased the evaporation. The intermediate stations, although selected with care, did not possess altogether uniform conditions as regards the movement of air and the character of the surrounding materials. While these doubtless influenced the results to some extent it is safe to conclude that altitude was the controlling factor.

EVAPORATION LOSSES FROM IRRIGATED SOILS.

The rate of evaporation from a water surface depends, as we have seen, chiefly on the temperature of the water and to a less extent on the

FIG. 4. EVAPORATION TANKS AT BERKELEY, CAL.

FIG. 5. EVAPORATION TANKS AT TULARE, CAL.

temperature and humidity of the surrounding air, velocity of the wind and altitude. These likewise influence the evaporation from irrigated soils, but in the case of the latter there is an additional factor which surpasses all others in its effect. This is the amount of moisture in the top layer of soil. Hence it follows that no reliable comparisons can be made between the evaporation from soil and water surfaces, without taking this condition into consideration.

In carrying on experiments to determine the evaporation losses from soils the chief difficulty is in securing natural conditions. Laboratory tests are easily made, but the evaporation from soils in the artificial surroundings of a laboratory is likely to be quite different from that of similar soils in the open field. On this account it was decided when the work was first planned to conduct all experiments of that nature in the open field. The plan followed was to obtain from a field 300 to 1,300 lbs. of soil, place it in a vessel as nearly as practicable in its natural position, and by periodical weighings ascertain the loss of moisture from the soil. Natural conditions as regards sunshine, wind and rain were easily obtained, but it was more difficult to maintain in

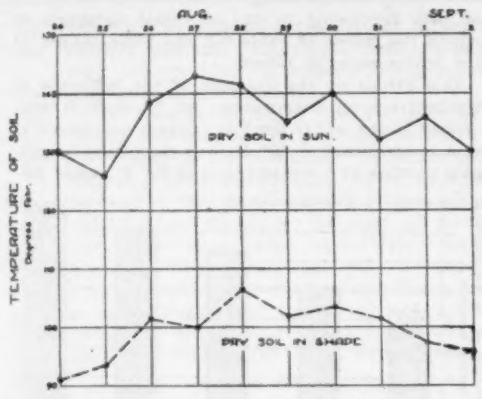


Fig. 6. Effect of Shade in Reducing Soil Temperatures.

of eight tanks and lightly tamped in 2-in. layers. Each tank was surrounded by a larger tank, with water filling the annular space between, and both were inserted in the ground midway between the rows of trees. The eight tanks were

heavy, while at the end of a ten-day period it was practically nothing. Fig. 12 gives the average of the daily losses from the five different methods of applying water. It may be well to add that the loss from surface irrigation was much greater than from shallow furrows and that the deeper the furrow the less was the loss from evaporation.

The same fact is illustrated by the results of an experiment given in table below, the main object of which was to compare the evaporation from water with that from soils containing different percentages by weight of free water.

The principle that the rate of evaporation from soils varies directly with the amount of moisture in the top layer has received little consideration in the past. Yet it appears to lie at the foundation of good irrigation practice. To ignore it can but result in much waste of water. He who keeps the surface of his fields moist by long-continued or frequent irrigations will lose by evaporation a large part of the water applied. On the other hand, he who keeps the top soil dry or wets it only at long intervals and cultivates often and thoroughly will conserve the greater part in the soil.

FIG. 7. SOLDIERS' CAMP, ON LONE PINE TRAIL; 4515 FT. ELEVATION. FIG. 8. SUMMIT OF THE MOUNTAIN; 14,502 FT. ELEVATION.
FIGS. 7 AND 8. EVAPORATION TANKS ON MOUNT WHITNEY, CALIFORNIA.

the soil within the tanks the same temperature as that in adjacent soil. This difficulty was overcome by using double water-jacketed tanks. The results of numerous observations showed that the temperature of the water which was confined in the space between the outer and inner vessels was practically the same as that of the adjacent soil which had not been disturbed. The ease with which a tank holding soil could be raised and

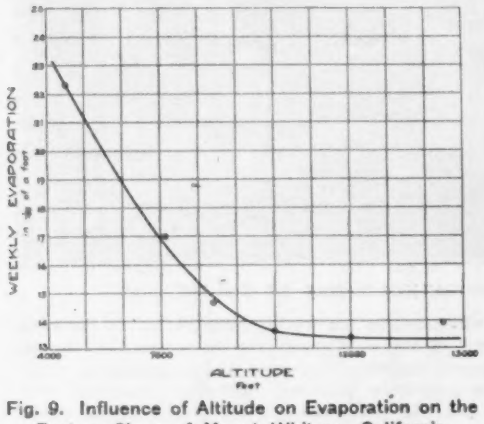


Fig. 9. Influence of Altitude on Evaporation on the Eastern Slope of Mount Whitney, California.

weighed and lowered was another advantage of water-jacketed tanks.

The effect produced on evaporation by varying the moisture content of the player of soil is clearly shown in the results of an experiment conducted in an orange orchard near Riverside, Cal. The soil was a sandy loam and had not been irrigated for several months. It contained on an average 5.16% by weight of free moisture. Nearly half a ton of this soil was placed in each

divided into four groups, the experiments being run in duplicate. The first group received no water, the second a very light irrigation, the third a light irrigation and the fourth an ordinary irrigation. The tanks were weighed daily and the evaporation loss from each was restored by adding an equivalent weight of water to the soil. The results of a ten-day test are given in the following table:

Number of tanks.	Initial weight of soil and tank, lbs	Amount of water added, lbs.	Loss by evap. in 10 days, lbs.
1 & 3.....	962.4	0	6.3
2 & 4.....	940.8	40	15.4
5 & 7.....	941.5	70	19.1
6 & 8.....	950.0	100	23.9

The same results are shown graphically in Fig. 10.

A similar experiment was tried at Tulare, Cal., in which 12 tanks were used. In the diagram, Fig. 11, which represents the results, the amount of water applied is directly proportional to the amount evaporated, so that the relation between the two may be expressed in the form $x = ay + b$.

In still another test eleven water-jacketed tanks were used. In each pair of these the irrigation water was applied at different depths. Two tanks received water on the surface, and the remainder in furrows from 3 to 12 ins. deep. The loss by evaporation in each pair for a period of ten days seemed to obey this same natural law. For a period of about two days after water was applied the evaporation was

INFLUENCES OF SOIL MULCHES IN CHECKING EVAPORATION.

This reference to cultivation calls to mind the investigations that were made regarding the effect of soil mulches on evaporation. Soil mulches are extremely important in the irrigated fields of the arid region. They not only prevent an excessive waste of water by evaporation but they absorb the rainfall, lessen the run-off, prevent the rise of injurious as well as beneficial salts

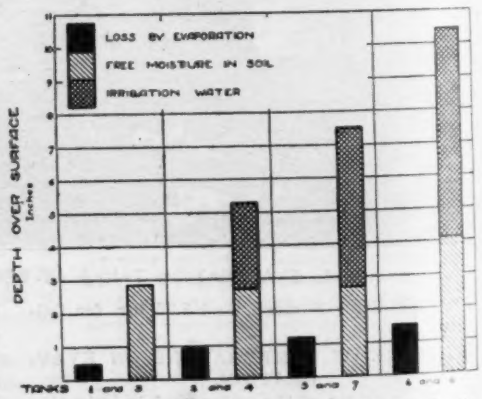


Fig. 10. Initial Amount of Free Moisture in the Soil, Amount Added, and Loss by Evaporation, at Riverside, Cal., July 27 to Aug. 5, 1905.

EVAPORATION FROM SOIL AND WATER.

Kind of soil and percentage of free water.	Mean temperature taken morning, noon and evening, in deg. F. Air in shade.	Soil in shade.	Soil in sun.	Moist soil.	Surface of water.	Weekly evaporation, ins. Soil.	Water.
Sandy loam—saturated.....	71	76	95	83	77	4.75	1.88
Sandy loam—17.5.....	76	78	106	..	80	1.33	1.94
Sandy loam—11.9.....	76	78	106	..	80	1.13	1.94
Sandy loam—8.9	76	78	108	..	80	.88	1.94
Sandy loam—4.8	76	78	108	..	80	.25	1.94

to the surface, and enable the air to reach the roots of cultivated plants.

This experiment was conducted in the usual way by filling each tank (see Fig. 13) with soil, applying a known quantity of water and determining the evaporation by frequent weighings. In one group of tanks the water was applied on the surface, there being no mulch; the second group, 4 ins. of finely divided soil, sandy loam in character, was spread over each tank after it was irrigated; while in the third and fourth groups the depth of soil mulch was 8 and 10 ins., respectively. The comparative losses in 14 days after irrigation from a soil without mulch and from soils protected by 4, 8 and 10-in. mulches were in the ratio of 45.6, 12.9, 5.3 and 1. The average loss from each group is indicated in Fig. 14.

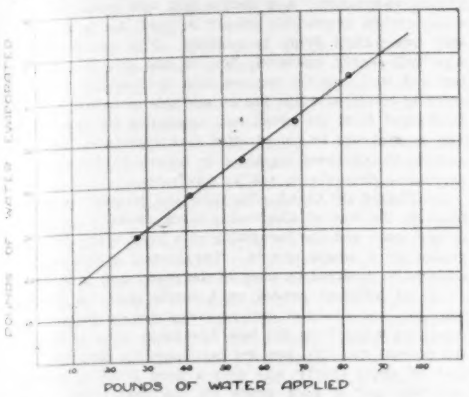


Fig. 11. Relation Between Amount of Water and Loss by Evaporation in Tulare Soils, June 15 to Sept. 15, 1904.

At the time the test was made the weather was quite warm and dry. The temperature of the air in the shade at noon was frequently over 100° F., and the temperature of the soil in the sun varied at midday from 120° to 140°. It would therefore appear that soil mulches of the requisite depth and texture afford a complete protection against the loss of water by evaporation from moist soil, even in a semi-tropical climate.

As Dr. Hilgard has so frequently pointed out, the chief difference between eastern and western soils lies in the greater depth of the latter. Orange trees, although naturally shallow-rooted, not infrequently draw moisture and plant food from the eighth foot in depth. The English walnut does not bear successfully in less than 10 ft. of rich soil, and deciduous fruit trees of all kinds grown in the arid region have as a rule deep root development. In view, therefore, of the value and scarcity of water and the abundance of rich soil, it is true economy to utilize the top layer of dry soil to protect the moisture beneath. This blanket of dry, pulverized soil resting on the surface of cultivated fields would save an enormous volume of water which is now vaporized by heat and drought.

Engineering News has done a good work in advocating the lessening of waste in domestic water supplies. It has repeatedly called attention to the fact that many of the large expenditures for the construction of works to furnish additional water supplies for cities might have been much reduced if proper measures had been taken to check the waste. The West needs the services of the same journal to mold public opinion to such a degree that the leaders of state and national policies, as well as the engineering profession, will be led to realize that it is more profitable to expend a small sum in checking the waste of irrigation water than a large sum in building new works.

THE PREVENTION OF DUST AND DISINTEGRATION ON MACADAMIZED ROADS IN CHICAGO.

The improvement of macadam roads by sprinkling them with compositions designed to prevent dust, and also to prevent disintegration of the surface (especially by automobiles), has been tried in various places and with various compositions. An additional advantage of successful treatment of this kind is in reducing the amount and cost of sprinkling in dry weather. This subject was discussed in our issues of Feb. 8 and 22, 1906, in connection with experiments made by the South Park Commissioners, of Chicago, and we have lately received further information as to the results obtained.

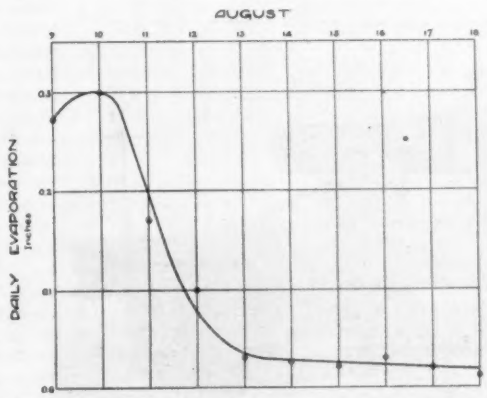


Fig. 12. Daily Rate of Evaporation for 10 Days After Water is Applied.

FIG. 13. LARGE SOIL TANKS, TRACK FOR PLATFORM SCALES AND IRRIGATING VESSELS USED AT RIVERSIDE, CAL., IN STUDYING EFFECT OF SOIL MULCHES OR CULTIVATION OF IRRIGATED LAND.

These experiments began with the use of a material termed "westrumite," which was a petroleum product. The commission is not now using this material on any driveways, but it is extending the use of "tarvia," which is a coal-tar preparation made for the same purpose. Mr. Linn White, chief engineer for the commission, informs us that this year it is also trying a California crude oil, and a preparation known as "asphaltoilene," made from Kentucky crude oil. The oiled streets have not been in use long enough to allow of judgment being passed on the results, but they promise well. The cost of application differs very slightly from that of the "tarvia." The last material has been applied on about 106,340 sq. ft. of driveways, and the results have been satisfactory in maintaining a good surface under general light traffic. On Michigan Ave., however, between 22d and 39th Sts., the material gave good results for only about two or three months. It was put on during the summer of 1906, but only 25% to 50% of the surface in the various blocks now retains its coating; the rest has been worn away under the traffic. It is considered that the traffic conditions there are too heavy for the treatment, and the South Park commissioners are now preparing to lay a more permanent pavement. The treatment has, however, given excellent results on Grand and Drexel boulevards, where the traffic conditions are less trying than on Michigan Ave. On different streets the amount of material used has been from 2½ to 3 gals. (and in one case nearly 4 gals.) per sq. yd. The average cost has been 6.1 cts. per sq. yd. (from 4.5 to 6.2 cts.). This includes picking up, harrowing and rolling the old surface, applying the material and a top dressing of screenings, and finally rolling the new surface.

The following description of the treatment is from information furnished by Mr. White to the Barrett Mfg. Co., of New York and Chicago, which manufactures the material in question.

In preparing for the "tarvia," the surface of the macadam was first cleaned, and the upper 3 ins. of the macadam then thoroughly loosened with picks in the wheels of a road roller. This was followed by a team with a harrow. The macadam along the edges of the drive was loosened by hand. The surface was then thoroughly sprinkled, rolled with a 10-ton steam roller and allowed to dry. The "tarvia" was then distributed from buckets and a layer of limestone screenings was rolled in with a steam roller. After 24 hours, traffic was admitted. The "tarvia" penetrated the macadam to a slight depth only, and in some cases the coating was not over ⅛-in. thick. It effectually protected the macadam, however, against the action of the motor-car wheels so long as it remained intact. At the same time, the necessity and cost of sprinkling were greatly reduced, the estimated saving being about 60%. Practically the only sprinkling required was that necessary to lay the dust blown on the treated surfaces or brought upon them by traffic. As sprinkling a 40-ft. macadam drive has been found by the South Park Commissioners to cost on the average $97.37 per mile per month during the season of 8 to 9 months, the actual saving in sprinkling alone is considerable.

44-IN. GAS ENGINE CYLINDERS for 54-in. stroke are being built in a type of gas engine developed by the Allis-Chalmers Co., Milwaukee, Wis., for the power-houses of the Indiana Steel Co., at Gary, Ind. These are claimed to be the largest cylinder diameters of any engines built in this country. These engines are 4-cycle, twin-tandem, direct-acting types designed to give 4,000 HP. on blast furnace gas of 80 to 85 B. T. U. and up to 5,000 HP. on richer gases. They are intended for direct connection to alternating-current generators. The crank pins are 20 ins. in diameter, the shaft 30 ins. and the fly-wheel 23 ft. The fly-wheel weighs approximately 200,000 lbs. and the entire engine, roughly, 1,500,000 lbs.

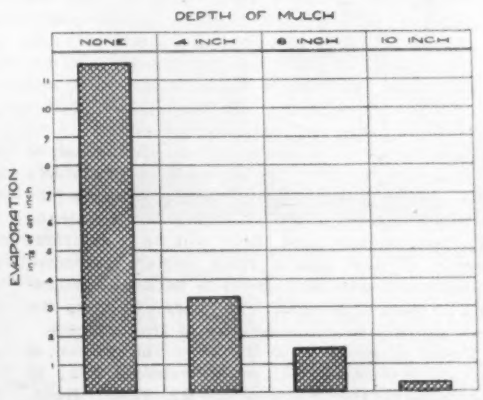


Fig. 14. Evaporation From Soils Protected by Soil Mulches of Different Depths.

PRELIMINARY BULLETINS anent the International Mining Exposition, to be held in Madison Square Garden, New York City, May 25 to June 20, 1908, are already out. At the annual election of officers of the International Mining Exposition Co., held on Aug. 21, Wm. M. Porter was re-elected President; Alvah W. Gifford, M. Am. Inst. M. E., of El Paso, Secretary of the International Miners' Association, was elected Vice-President, and J. C. Young, Secretary of Madison Square Garden, Secretary. Replies received to communications to officials of foreign governments and our own states indicate that the exposition will be widely representative and successful.

LARGE ROCK-CRUSHING AND STONE-HANDLING PLANTS AT QUARRIES.

In rock-crushing plants at quarries, a considerable amount of time and labor is generally expended in breaking up the larger masses to sizes that can be fed to the crusher, as to shatter the rock into small pieces by blasting would involve heavy expense. The pieces which are too large for the crusher are generally broken by hand. An important feature in the design of rock crushers, therefore, is to increase the capacity for taking in large pieces, in order to reduce the expense of blasting and the amount of manual labor required. The largest capacity in this respect appears to have been reached in some McCully crushers of the gyratory type for the quarries of the Dixie Portland Cement Co., Richard City, Tenn., and the Iowa Portland Cement Co., Des Moines, Ia. The spider supporting the cap of the crusher shaft has only two arms, and the machine can take in blocks 3 × 5 ft., with a length of 8 to 10 ft. The product is about 4 ins. to 5 ins. in size, and is sent to smaller crushers for further reduction. The hopper is 20 ft. in diameter, so that material can be dumped in at several points in order to keep the machine supplied. The machine exerts a crushing pressure of about 750 tons, and has a capacity of

CRUSHING HEAD AND SHAFT OF ONE OF THE LARGEST ROCK CRUSHERS EVER BUILT; DIXIE PORTLAND CEMENT CO.

output of about 1,000 tons per hour. It is driven by an electric motor of 250 HP. The machine is 20 ft. 6 ins. high and stands upon a concrete foundation 30 × 21 ft., with a depth of 9 ft. The total weight is about 212 tons, and the parts are made as large as transportation conditions will allow. Thus, the lower shell weighs 36 tons, the upper part of the shell is made in two pieces weighing 22½ tons each, and the shaft, with the crushing head in place, weighs 34 tons. The accompanying view shows the gyratory shaft and crushing head of one of these machines, loaded on a 50-ton steel flat car for shipment.

At both of the quarries, special means are to be taken to facilitate the handling of the broken rock without manual labor. At the working face it will be loaded into 6-ton dump cars by means of steam shovels, and there will be a sufficient supply of cars and a track system extensive enough to enable the shovel to be kept continually at work at the face. The cars will dump the rock directly into the hoppers of the crushers.

These crushers were built by the Power & Mining Machinery Co., of Milwaukee, Wis., to the general specifications of Mr. Leigh Hunt, President and Chief Engineer of the Hunt Engineering Co., Iola, Kan., which company has designed the complete plants for the two Portland cement companies mentioned.

A DIRECT SUBMARINE CABLE from New York City to Havana is to be laid for the Commercial Cable Co., to reduce the time of transmission now obtaining via the Florida route. As it is at present, messages are transmitted from Havana to the Florida coast, thence to be transmitted over land lines to New York City. The cable steamer "Silvertown" sailed from London on Sept. 12 with 1,300 miles of cable on board.

ELIMINATING SMOKE WITH LOCOMOTIVES BURNING SOFT COAL.*

This committee has undertaken to obtain individual statements and information throwing light upon the subject of the best means of eliminating the smoke nuisance from locomotives burning soft coal, and its report is based upon the information obtained.

(1) STEPS TO REDUCE THE SMOKE NUISANCE.—In almost every case the first step is to educate the firemen, for no matter what the other conditions may be it is impossible to avoid black smoke without intelligent and faithful work on the part of the firemen and enginemen. In one or two instances the problem was put up to the engine crews entirely, the road holding them responsible for any excess of black smoke ,and suspending both men when no good excuse could be given. Smoke inspectors are employed on certain roads. Their duty is to instruct firemen, and to look into cases where too much black smoke is being thrown off; also to find first the cause and then the remedy.

Mechanical devices are in use on several roads to assist the fireman, and almost without exception these are showing good results. The further experimenting with practical devices for assisting the fireman in his exhausting work must receive more thoughtful attention on the part of railway managements, the modern massive engines having made proper firing almost beyond the physical powers of the fireman, no matter how faithful he may be, unless aided by mechanical means. The pneumatic fire box door closer has been strongly advocated. Automatic stokers are claimed to not only relieve the fireman, but also to spread the coal better and avoid the necessity of opening the door and drawing cold air over the fire.

The use of the hollow brick arch is also advocated, the claim being made that better combustion results from its use, and therefore a diminishing of black smoke, although one correspondent maintained that the good results obtained from brick arches did not compensate for the cost of maintaining them in wide fire boxes. Smoke consumers, consisting of a strong blower in the front end and steam jets into the fire through the side sheets, were said to give good results if the engine was fired light.

(2) PREPARING COAL BEFORE DELIVERY TO THE TENDER.—Only a few roads prepare their coal, and these get good results. The general method is to break the large pieces into lumps from 4 to 6 ins. in diameter. One method which appears practical and inexpensive is to provide coal sheds with breakers made by placing ¾ × 3-in. iron bars set on edge about 5 ins. apart. On these the coal is dumped and must be broken into pieces less than 5 ins. diameter before it will fall through. The value of such practice should not be overlooked by railway companies.

(3) PREPARING THE FIRE BEFORE STARTING.—Almost without exception the fire is built up gradually until a good level bed is secured, of sufficient thickness to hold without tearing under heavy exhaust, and thereafter the single-scoop system is used in replenishing the fire. When stops are made the fire should be in such prime condition that it will not be necessary to put on much green coal when starting, and the engineman should use every effort to assist the fireman in holding his fire by pulling out carefully. When the stop is to be a short one, the fireman should endeavor to have his fire in such condition that no green coal need be added until the train has left the station. The blower should be used to pull just enough air through the fire to combine with the gases, and grates and ash-pan should be kept clean and in good condition. The condition of grates has much to do with the suppression of black smoke.

*Abstract of a report presented at the annual meeting of the Traveling Engineers' Association, Chicago, Sept.

(4) INSTRUCTIONS TO FIREMEN.—All replies indicated that firemen were instructed to fire as lightly as possible, from one to four scoops at a time being advocated. The one-scoop system seems to be in universal favor, but in some instances it is deemed impractical on account of the modern large fire boxes and the limit of human endurance. Any device that will make the one-scoop system practicable should be tried, for in no other way can perfect firing be possible. The coal should be well and evenly scattered, first on one side of the fire-box and well into the corners, and then on the other, in order to retain a bright fire on one side to burn the gases discharged from the green coal applied to the other side. The door should be closed after each shovelful is applied, and for this purpose (in order to relieve the fireman) the pneumatic door closer has its advocates.

(5) GRADE OF COAL.—Probably the greatest stumbling block in the way of eliminating black smoke is the grade of coal used and the furnishing of a great many different grades on a single system. The poorest grades of coal seem to be received by most of the roads, and as many as 17 or 18 different grades on a single road. A fireman who gets one grade of coal regularly and becomes accustomed to using it to the best advantage (even if it is of the poorest quality), can get better results than the fireman of equal ability who gets a good grade of coal on one trip and a poor grade on the next. One report indicated satisfactory coal conditions. In this instance 50% of bituminous and 50% of anthracite coal was used, and little trouble was experienced from smoke, as it could be regulated by increasing the percentage of anthracite at times when excessive smoke was objectionable.

Fine coal is found to produce more smoke than lump, as it ignites more rapidly and the smoke and gases formed have less chance of being burned off. This is also true of the lighter grades as compared with the heavier. It is more difficult to prevent smoke with coking coal than with non-coking, and still more difficult with slack coal. Where several grades are in use there is no benefit derived from the use of the best grades (except that they produce steam more satisfactorily), because the fireman does not get the good coal frequently enough to become accustomed to firing it properly.

(6) COMBUSTION CHAMBERS.—In one case combustion chambers were used, but discontinued on account of steam failures and the banking of cinders and fire against the lower flues, causing them to leak. In another case they were said to have given good results in generating steam, but were condemned on account of faulty construction. In another case combustion flues or tubes are being used with good results. There has evidently been experience in this direction.

(7) VARIABLE EXHAUST.—There has been too little intelligent experimenting with appliances to soften the exhaust when starting. This seems strange in face of the fact that such splendid results are being secured by their use in other countries. One report stated that no noticeable results had been shown, while the other reports from roads where they had been used were very favorable. In two instances the statement was made that considerable experience with auxiliary exhaust devices had demonstrated their value, not only as smoke reducers, but as coal savers, on account of their equalizing the draft through the fire box, and thereby making lighter and more systematic firing possible. Faulty construction was the only unfavorable comment in another instance, and this is undoubtedly the reason for the hesitancy most roads show in testing these devices.

CONCLUSIONS.—The present tendency toward still heavier power must necessitate a change in the old methods of handling a locomotive. Mechanical devices to assist the fireman in the duties that now overtax his strength must sooner or later be put in use, both in the interest of economy to the company and in fairness to the engineman. What devices will best accomplish the desired results is still a question, for the reason that the managements of railways are backward in taking up anything that looks like an additional expense in maintaining power, while the mechanical departments dread the trouble and nuisance of experimenting with new devices. The enginemen themselves are probably as much to blame for blocking changes that are bound to come at no distant date. Any old timer knows the aversion of the engineman to any new appliance on his engine, and can remember the storm of disapproval that met the invasion of the injector, the lubricator, and the air pump, but these devices stuck because new conditions made them necessary, just as new conditions to-day are making necessary new devices.

The answers received by your committee indicate that this report could safely recommend several things.

(1) The preparation of coal before it is put in the tender is recommended, because the expense of such preparation is light, and coal so prepared can be fired more uniformly and will give better results. The fireman is saved the additional labor of breaking up big lumps.

(2) The single-scoop system of firing with the closing of door after each scoopful is recommended because in this manner all the gases are given a chance to become properly mixed with the air drawn through the grates

and to burn off with the least emission of black smoke. More water can also be evaporated with a given amount of coal and the fire kept in better condition.

(3) The standardizing of the grades of coal used is approved because the suppression of black smoke and economical firing is impossible when firemen must contend with a continual change in the quality of the coal they must use.

(4) A more conclusive test of the brick arch is desirable because the tests so far made show that gases and smoke given off by the coal are more thoroughly burned in fire boxes equipped with brick arches, and less black smoke is given off.

(5) A wider investigation of the pneumatic fire box door closer and the mechanical stoker should be made, because the steady increase in the size of power will in all probability necessitate the adoption of some such devices in the interests of economy and the firemen.

(6) A conclusive test of the auxiliary exhaust is advisable because, with the modern large power with its high steam pressure and great volume of exhaust, light and economical firing is practically impossible without some method of equalizing the draft through the fire-box and softening the exhaust when working in full stroke and under heavy throttle.

STRENGTH TESTS OF A CONTRACTOR'S DUMPING WAGON.

A rather unusual kind of strength test was recently carried out by Prof. W. K. Hatt, at Purdue University. The manufacturers of a special type of dumping wagon for contractors' use desired to have made experiments which would show the strength of the wagon against the principal forces of attack in service, and commissioned Prof. Hatt to conduct such experiments. The tests devised for this purpose, and their results, as reported upon by the experimenter, have been published in a pamphlet, "Tests of a Dumping Wagon," which may be obtained, we believe, from the Troy Wagon Works Co., of Troy, O. From a copy of this pamphlet recently given us by Prof. Hatt we abstract the following summary:

Four tests were planned and executed. Two of these concerned only the strength of a rear wheel, one the strength of the rear axle, while the fourth involved the entire body and underframe of the vehicle. The four tests thus covered all the main parts except the draft attachment. Incidentally, a pointer on the permanent

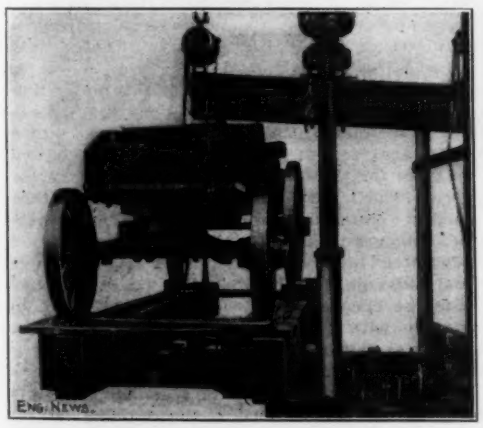


Fig. 1. Arrangement for Load Test of a Dumping Wagon.

G. Timber platform resting on a steel girder E placed across the testing-machine platen.
B. Straining-beam, bearing on sills placed on sand filling the wagon-box. The beam B is supported at the other end by a wooden post resting on the far end of girder E.
C. Pulling head of testing-machine.
A. Pulling screws of testing-machine.

tightness of the bottom doors was obtained in the load test of the complete wagon.

As a testing-machine platform is too small to allow setting the wagon on it, a special rigging was necessary. Across the platform of a testing-machine was placed a stiff steel girder. A timber platform, on which the wagon was set, was built on one end of the girder, while on the other end was set a wooden post adapted to serve as fulcrum for a load-applying lever. The latter, a steel I-beam spanning from the fulcrum post to suitable distributing blocking on the wagon, was engaged at mid-length by the pulling head of the testing-machine. The machine, then, weighed the total applied load and the total dead load of the rigging. Of the applied load only half came upon the wagon. To distribute the pressure on the wagon in a manner simulating the effect of service loads, the wagon-box was filled

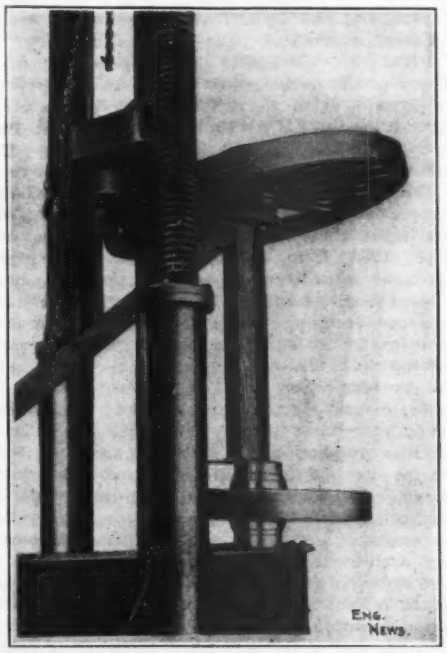


Fig. 2. Arrangement for First Wheel-Test.

The rear axle is held and braced in vertical position, and a wooden strut between the hubs carries the vertical load applied to the upper wheel. The straining head of the testing-machine presses down on the rim of the upper wheel.

with sand to the top of the sides, sills placed on top of this sand but not touching any part of the wagon body, and blocks placed between these sills and the straining-lever. Thus the applied load was brought to bear, through the sand, upon the bottom of the box, except in so far as the friction of the sand transmitted some of the load to the side-boards. Fig. 1 shows the arrangement. Failure occurred under an applied load of 72,500 lbs. This figure, divided by the capacity of the wagon, 8,500 lbs., gives a safety-factor of 8.53. The failure occurred in the neck of the side-plates, by shearing of the rivets, which was preceded by cracking and longitudinal shearing in the same region.

The test of the rear axle, which is directly related to the preceding test, was made by arranging supports and loads exactly the same as they occur in the wagon. A rear axle, with stripped hubs, was set on a pair of rollers set transversely at mid-length of the hubs, giving a span of 4 ft. 4⅞ ins. Equal loads were applied at the spring seats, which are 2 ft. 8¼ ins. apart. Failure occurred between 26,000 and 29,650 lbs. applied load, though the maximum load was 31,000 lbs. The greatest deflection, just before the axle buckled downward, was 1.20 ins.

The two wheel tests were designed to gage (1) the resisting power of the wheel to the forces which act when the loaded wagon stands on a steep side-hill, and (2) the strength of the wheel against the twisting action occurring when the wagon is turned out of a deep rut. For the first purpose, the rear axle with its wheels was mounted vertically as shown in Fig. 2, in such position that the pulling head of the testing-machine could press downward on one side of the rim of the upper wheel, while the axle and hub were held vertical. The strength determined in this test was exactly the same as that brought into play when the wagon stands on side-hill as stated. The maximum possible load in such a case would occur with such load, and on such a slope, that the wagon is just on the point of tipping over. On this basis the test (5,500 lbs. failure load) showed a factor of safety of 2.05 in the wheel. While it is conceivable that a greater lateral pressure against the wheel-rim might occur on a very steep slope after the wagon has begun to tip over, this is hardly to be considered a service condition.

The other wheel test, intended to simulate the twisting action which occurs when a driver attempts to turn out of a rut, was made by clamping the sides of the rim, at one point, between a pair of vertical beams, and pressing down by

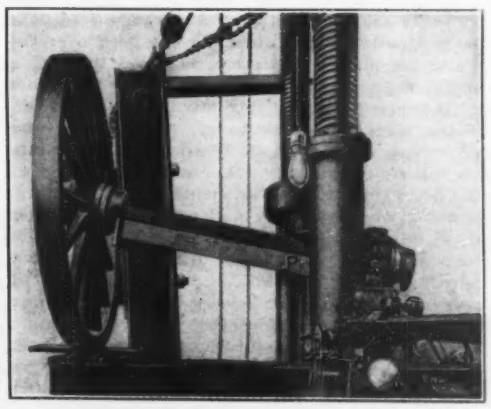


Fig. 3. Arrangement for Second Wheel-Test.

C. Clamp fastened rigidly in vertical position, fixing direction of rim of wheel at one point.
R. Rollers under wheel to take reaction of twisting force.
P. Point of loading (43 ins. from center of hub).

means of the testing-machine on the far end of the axle. Fig. 3 exhibits this quite well. The failure load, 3,650 lbs., exerted a moment of 13,080 lb.-ft. Prof. Hatt computes that if the

TABLE I.—LOAD TEST OF COMPLETE WAGON.

Gross Load on Wagon	Remarks.
40,500 lbs.	Front Bolster down on arches.
44,500	Sides of body shearing along boards.
48,500	Side boards cracking at neck.
62,500	Sides down on rear hubs.
72,500 [Maximum].	Rivets sheared in neck-plate next to butting, both sides.

Note: At the load of 62,500 lbs., the various distortions measured were as follows: Widening of neck 0.30 (measured only up to 53,000 lbs.); sagging of bottom of box at center, 3.97 ins.; vertical sagging of sides of box with reference to fixed points over the axles, 2.67 ins.; deflection of spring on rear axle, 2.21 ins.; deflection of rear axle, 0.53 in.; whole vertical movement of wagon with reference to bottom of wheels, 3.13 ins.; change of diameter of rear wheel, 0.15 in.

Wheels, axles and bolsters showed no signs of failure. The chains were intact. The bottom of the box sagged 4.37 ins. (at 68,500 lbs. total load) but did not leak sand. The dumping mechanism, worked after the test had dumped the load. The springs over the rear axle were uninjured.

TABLE II.—BENDING TEST OF REAR AXLE.

Supports at centers of hubs. Span 52⅞ ins.
Loads applied at spring seats, 16½ ins. either side of center line.

Deflections measured at mid-span. Total load, lbs.	Deflection, ins.	Set, ins.
10,000	0.15	0.00
20,000	0.30	0.01
26,000	0.40	0.04
28,000	0.55	0.15
29,650	1.20	
31,000 [Maximum].		

Note: At 26,000 lbs. axle began to fail at two points 9 ins. from load toward center.
At 29,650 lbs. axle buckled downward.

TABLE III.—SIDE-HILL TEST OF REAR WHEEL.

(Test arrangement shown in Fig. 2.)

Transverse load on rim, lbs.	Remarks.
4,444	Slight cracking.
4,500	Spokes giving in hub.
5,150	Spoke slipped in hub.
5,400	Spoke cracked.
5,500	Five spokes lifting out of hub.

After the test the deflection of the rim was 5 ins. (at end of spoke.)

TABLE IV.—TWISTING TEST OF REAR WHEEL.

(Test arrangement shown in Fig. 3.)

Load on axle, lbs.	Twist of wheel at end of spoke, lbs.	Remarks.
1,000	0.31	
2,000	0.61	
2,500	0.83	
3,000	1.14	
3,400	1.64	Spoke giving in hub
3,650 [Maximum[.	1.99	Spokes giving in hub and rim.

Note: The upper spokes yielded more than the lower ones, the latter being strengthened by the dish of the wheel.

horses hitched to the wagon were to turn so as to pull directly sideways (leverage of 9½ ft. from king-bolt to rear axle) with a pull of 800 lbs. maximum, they would apply a twisting moment of 7,600 lb.-ft. Even if this were concentrated on a single rear wheel, the resistance found by test would still give a factor of safety of 1.72.

A condensation of the tabulated test results, together with the measurements, etc., of the wagon, is as follows:

MEASUREMENTS, ETC.

Troy bottom-dump wagon No. 5½	
Rated capacity	8,500 lbs.
Weight as tested	2,410 lbs.
On front axle	1,211 lbs.
On rear axle	1,199 lbs.
Weight of body	1,386 lbs.
Rear wheel, diam	4 ft. 5 ins.
tire	4 ins.
spokes	2¾-in. size
hub	9½x11½ ins.
weight	208 lbs.

ANNUAL CONVENTION OF THE NEW ENGLAND WATER-WORKS ASSOCIATION.

The twenty-sixth annual convention of the New England Water-Works Association was held at Springfield, Mass., Sept. 11 to 13, 1907. Some 235 members and guests were in attendance. In addition to the technical features of the meeting, noted below, the last day was devoted to excursions in the morning to the works of the Chapman Valve Mfg. Co. at Indian Orchard and in the afternoon to the filtration plant of the Springfield water supply at Ludlow and to the United States Armory in the city of Springfield.

TECHNICAL PAPERS.

THE SPRINGFIELD WATER-WORKS.—The first paper on the program was "The Springfield Water-Works," by Mr. Elbert E. Lochridge, Chief Engineer of the Springfield Water Department. Mr. Lochridge traced the development of the water supply of Springfield from its institution to the $2,000,000 addition that is now in course of construction. Springfield at present gets its water from a series of small creeks joining at storage reservoirs at Ludlow, about 12 miles east of the town. This plant was built in 1872, at the time when the city took over the water supply from private owners. In 1892 a large addition was made in order to take care of the constantly growing city. The plant consisted merely of a series of storage reservoirs delivering water without treatment directly into the mains of the city. For a large portion of the year the supply was eminently satisfactory, but for about three months in each summer there appeared in the water organic growth to such an extent as to make its use for drinking purposes almost impossible. In 1905 a series of open-top sand filter beds were constructed which were to be used during the period of organic growth to remove the bad taste and odor from the water. At first these filters did not serve their purpose, but with certain changes and additions they have been quite successful.

However, the supply at present is insufficient for the needs of the city, and a new plant is now in process of construction. The source of this supply is in a direction opposite from the old one. The water is collected from the watershed of a mountainous stream, known as Little River, which flows between steep banks in an almost uninhabited country. Filtration beds are to be used, although for ordinary purposes the raw water would be perfectly safe. An additional advantage is gained in a distributing reservoir very near the source of supply. The new supply is at a much greater elevation than either the old one or the city, thus solving one of the large problems in its selection, namely, a high-pressure fire service line.

The paper was discussed by a number of members, notably by Mr. Allen Hazen, one of the consulting engineers on the work, who said that five years ago Springfield had the worst water supply of any city of size in Massachusetts, but that when the new work is finished it should have the best.

The first evening session was opened with an illustrated talk by Mr. Allen Hazen upon his recent trip to Australia as consulting engineer for the Brisbane Water Board. The lecture was largely non-technical but gave a clear idea of the natural and social features of this large and, to most Americans, little-known country.

PEABODY WATER SYSTEM.—The other paper of the evening was by Mr. F. A. Barbour, of Boston, upon the "New Water-Works Plant at Peabody, Mass." The water system at Peabody is one of the oldest in this country. The following chronological data show the growth of a typical pipe line designed only for the existing generation and replaced by the next: 1797, 3-in. log pipe; 1804, 5-in. log pipe; 1834, 6-in. iron pipe; 1850, 12-in. iron pipe; 1865, cement and wrought iron 15-in. pipe. The plan was purchased from a company in 1873, and at that time changed from a gravity to a pumping system. The needs of a larger service have recently necessitated the enlargement of the plant, and the present paper was largely devoted to a detailed description of the new works. The leading point of interest in the new system is a large circular masonry reservoir which has been built on the crest of one of the historical hills around Salem. On account of the sentimental interest connected with this site special care was taken to construct a reservoir and gate house of pleasing architectural appearance. The exterior of the reservoir is of coursed ashlar and the gate house is of a similar construction, topped with an observation tower which commands a magnificent view of the ocean and surrounding country. In view of the many unsightly appendages to the water-works of this country the attention paid to artistic details in this work is commendatory.

WATER RIGHTS.—The morning of the second day was devoted to papers and discussions on the subject of damages resulting from the diversion of water used for power. The first paper was by Mr. Charles T. Main, of Boston, on "Computation of the Value of Water Power." This paper was originally read by Mr. Main before the American Society of Mechanical Engineers, in 1904. It was presented before the present meeting in order to get it upon the records of this Association and to form a basis for the discussion upon the subject which it treats. The paper details the various items which go to make up the value of a water power and describes the methods by which the values are arrived at in determining the damages accruing to an owner the water from whose plant has been diverted for governmental use.

This was followed by a paper by Mr. Richard A. Hale, on "Water Rights." As long as only one mill is using a given power the amount of water used is rarely a cause of dispute. But when more than one company are using the same or allied powers it becomes necessary for the rights of each owner to become clearly defined. On account of lax deeds in the past the amount of water allowed under the deed is often largely a matter of conjecture, and this uncertainty as to meanings of obsolete contracts is one of the greatest sources of trouble. For this reason it is imperative that the rights of power should be put in language mathematically capable of being understood at some future time. Also, in order to have records of the amount of water used for evidence in any dispute which may arise, it behooves all mill operators to keep in service some method of gaging or measuring this flow. Mr. Hale, throughout his paper, cited numerous examples to illustrate the various points of his analysis.

In the discussion which followed the most attention was paid to the principle of "repaying in kind" for diverted water power. That is, the establishment, by the city or state diverting the water from any mill, of another water storage or supply from which the mill can get a power equally as good as the one taken away. This has been attempted in a few cases, but its legality has been questioned. It was the opinion of a number of the members that, should it be allowed by the courts, it would prove an efficient and just method of settling damages. Reference was also made to laws recently passed giving some of the state governments large powers over the water-rights of streams.

In an effort to adjust the wide divergence of estimated damages as made by the engineers for the mill-owners and by the state or city engineers, the association passed a resolution authorizing the president to appoint a committee of five to collect all available data on damages resulting from diversion of water and look toward a cooperation with a similar committee from the New England Cotton Manufacturers' Association, the joint committee to draw up rules for the guidance of engineers making estimates on damage suits. It is thought that the list of past awards and a set of rules for practice will do much toward standardizing estimates.

Papers by Mr. Frank E. Mills, of Woonsocket, R. I., and Charles E. Chandler, of Norwich, Conn., on this subject of "Water Rights," were passed over to the November meeting.

THE WALTHAM REINFORCED-CONCRETE RESERVOIR.—The afternoon session was started with a paper by Mr. Bertram Brewer, City Engineer of Waltham, Mass., on the "Waltham Reinforced-Concrete Reservoir." This reservoir is the fourth reinforced-concrete tank or standpipe of any size built in this country, and although not as high as some of the others, has the largest capacity. The tank is 100 ft. in diameter and of 35 ft. inside height. It is built on a ledge of solid rock, with a slab floor 12 ins. thick reinforced with wire mesh. The side walls are 18 ins. thick at the bottom, rising with constantly battered outside face to a 12-in. thickness. The walls are reinforced with horizontal circumferential 1⅛-in. round rods with 40-in. lap joints. The rods are spaced 12 ins. c. to c., vertically, in horizontal rows of three for the lower 20-ft. and in rows of two for the remainder. The walls are connected to the base by a curved inner surface and by 1⅛-in. rods, which extend 6 ft. into the base slab and are bent up into the wall for 3 ft. The top of the tank is covered with a steel truss roof, radiating from a concrete pipe support in the center.

In work of this sort the prime consideration, other than the strength, which is a matter of easy determination, is to make a waterproof structure. The Waltham reservoir has been filled with water for about a year and as yet no leaks have appeared. To reach this water-tight condition the following precautions in construction were taken. The sand and stone were carefully analyzed to procure the best mechanical mixture for the filling of the voids, and the material which went into the concrete was thoroughly cleansed before using. Two waterproofing compounds, the Medusa Compound and Hydrated Lime, were tested in trial mixtures, and although both showed good results the lime was the cheaper and hence was used in 5% by volume with the regular 1:2:4 mixture. Great care was taken in laying the steel that none of it should be loose and so easily jostled out of position when the concrete was half set, thus leaving holes. To ensure the stability of the steel, the horizontal reinforcing rods were set in vertical latticed angle and plate columns. The forms were tied together with detachable bolts, which left the center portion in the concrete when set. In joining new concrete to old at the day's work joints the old surface was carefully washed and all debris and laitance removed. Immediately before placing the new concrete, a light wash of cement grout was applied. In only one case has the slightest dampness shown at any of these joints, that place being one where from some needs of the erection plant concreting was shut down for five days in very dry and hot weather. As a final precaution, the entire inside of the reservoir was lined with a mortar coat. For the lower 9 ft. this coat consisted of a 1:3 cement mortar with 10% Hydrated Lime and 5% Medusa Compound; for the upper portion it was merely a cement grout. With the above precautions for waterproofing an entirely satisfactory structure has been completed.

The discussion following the paper consisted largely of the experience of various members in the waterproofing of concrete. Special attention might be called to an instance in East Orange, N. J., where a leaky concrete tank has been made watertight by a three-fold application of the so-called Sylvester process of coating with alternate layers of Castile soap and alum.

Mr. William R. Conard, of Burlington, N. J., presented a short paper on "Cast Iron Pipe Specifications," in which he advocated several minor improvements in the specifications on pipe now standardized by the association. A member of a pipe manufacturing firm stated in the discussion that one of the most needed improvements in pipe specifications was a rule requiring an extra 4 or 5 ins. to be cast in the spigot end of each pipe which should be removed just beyond the bead before the pipe left the shop, thus getting rid of the bad material which is extremely liable to run to that end.

THE CHARLES RIVER BASIN.—The last paper on the program was by Mr. Hiram A. Miller, Chief Engineer of the Charles River Basin Commission of Boston, on "The Charles River Basin." This basin is a water park now in course of construction on the Charles River, the pond in which is formed by damming the river near its mouth. A back water is thus formed extending a considerable distance up-stream and lined on either side by wooded parks. Outside of the great possibilities in landscape gardening on these park banks, the main points of engineering interest in the work are to be found in the construction of the sluiceways and lock through the dam at the lower end of the basin. The lock is built of sufficient size to permit the passage of boats with 17-ft. draft. It is of concrete masonry throughout, reinforced slightly, against temperature strains principally, and founded for most of its length upon pile footings. The concrete mixture is 1:3:6, crushed granite being used for stone. A mortar facing of 1:3 mix is applied to all inside surfaces. The showing surface of the dam, sea-walls and locks are of ashlar granite. Expansion is provided every 40 ft. by means of tenon joints filled with tar. By legislative order the lock must be workable in winter, so it was necessary to devise a unique system of heating the lock gates to prevent binding from ice. This has been solved by rolling gates working somewhat on the principle of the rolling lift bridge, built of hollow steel work, through which steampipes are run.

As the Charles at this point carries some of the storm water pipes of the combined sewer system of Boston, it was necessary to build marginal conduits along either bank which carry this excess sewage parallel to the stream and out

The larger portion of the construction work has already been finished; that which remains to be done is mostly in the decorative line.

A TRACTION ENGINE WITH DERRICK AND SHOVEL ATTACHMENT.

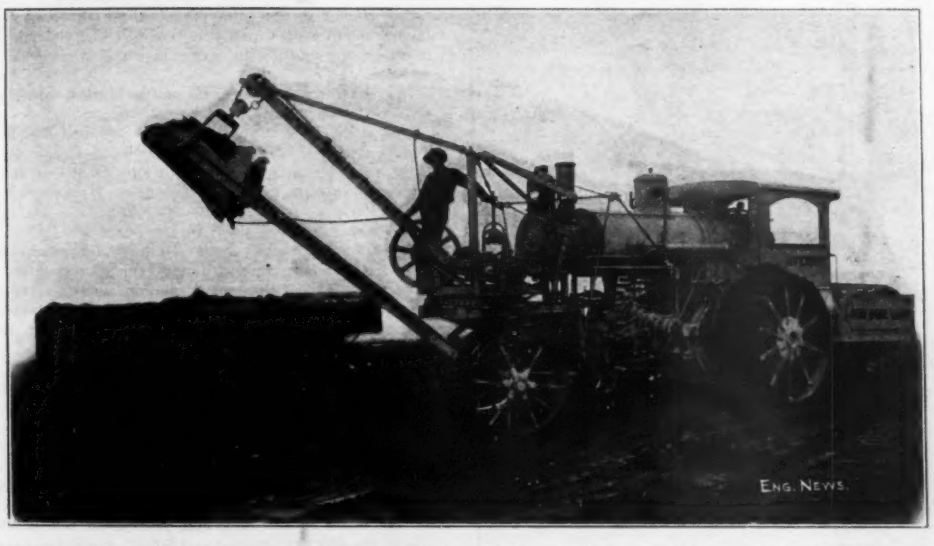
A novel development of the ordinary traction engine, introduced by the Avery Manufacturing Co., of Peoria, Ill., is illustrated by the adjoining photographic view. It is a traction engine for road construction and general contracting, fitted with a derrick and shovel attachment at the front end, which enables it to do surface excavation work and hoisting of moderate weights in addition to its regular work of hauling. The nature of this attachment is quite completely shown by the view, so that little needs to be said in the way of description.

The shovel arm is a fork arm, built of steel shapes, journaled at its rear end in a universal bearing carried at the front of the forward truck, and holding between the forward ends of its side bars a flat, wide shovel bucket, shaped something like the bucket of a wheeled scraper. This shovel is filled by the traction engine shoving it forward into the earth (or coal, gravel or other material to be loaded), and is then lifted and swung by the tackle of the derrick attachment above. The shovel has a capacity of about ¼ cu. yd. It is dumped by tripping a latch, the line from which leads to the derrick operator's position.

The derrick attachment comprises a turntable base, mounted on a frame bolted to the forward engine frame bolster; a triangular crane boom, carrying a hoisting drum, and held by a fixed backstay; and two pairs of steam cylinders, operating the hoisting drum and the swinging motion, respectively. The swinging motion operates by a vertical pinion shaft, driven from the swinging engine and carrying a pinion which engages a flat link chain fastened around the turntable drum. The steam connection to the engines is made by a hose from the main steampipe. The latter leads from the steam dome down along the side of the boiler and forward to the main steam cylinders, with a branch to the steering engine.

According to a statement of the builders, this machine, working as a shovel, can handle from 1 to 5 cu. yds. per minute, depending on the character of the material handled.

The traction engine which carries the hoisting and shovel attachment is designed on the general lines of a locomotive; the cylinders are carried at the sides of the main frame, taking all operating stresses out of the boiler, so that the latter has no service other than raising steam. The engine is ordinarily geared for speeds of 2½ to 3 mi. per hr., but has a change gear for higher speed—3½ to 4 mi. per hr. A steel tender, carried on a single wheel (18 ins. face), is fastened rigidly at the back of the main frame. Its supporting wheel has a frame rotable around a vertical pivot, and is turned for steering by a chain connection from the screw shaft of the front truck turntable. The tender has a water capacity of about 35 cu. ft.



AVERY UNDERMOUNTED TRACTION ENGINE WITH SHOVEL AND DERRICK ATTACHMENT.

A NEW BRITISH FUEL.

A new fuel called "coalite" is attracting wide attention in England, largely through an active advertising campaign. In the first reports that were received in this country, such extravagant claims were put forward that it was considered a fraud. In the prospectus of the British Coalite Co. a more complete description of this semi-coke is given than has heretofore been available in this country. It is described as an improved coal, obtained after a low-temperature distillation of the common bituminous varieties. This process is claimed to distill all the smoke-producing compounds, without breaking up the liquid hydrocarbons. In the coking process about twice as much liquid by-product and about half the usual amount of gas is obtained as in gas works. This lower temperature treatment of coal intended to produce a good domestic fuel and a large yield of liquid by-products is claimed as an advance of great importance to the general public. Coalite has been approved by the British Smoke Abatement Society as being entirely smokeless and superior to coal of the best quality. Among the other advantages claimed for the new fuel in the prospectus are: quick lighting; maintenance of a clear fire for several hours without attention, together with the possibility of a low fire which does not easily go out; adaptability to any grate, stove or furnace.

Calorimeter tests of coalite show a value of 13,500 B. T. U. per lb., as compared with 14,800 B. T. U. for the best of bituminous or semi-bituminous coals. It is stated that nearly all the heat in coalite is available for heating, while with bituminous coals a considerable part of the heat generated, especially in the early part of combustion, goes to breaking down and driving off the hydrocarbons which appear as smoke. Until this distillation is completed the fire burns "dead," and after completion only about 50% of the total number of heat units are available. The relative number of B. T. U. utilized in actual heating are placed at 7,500 and 13,800 with bituminous coal and coalite respectively. The prospectus claims that of the 13,000,000 tons of soft coals burned in London about 330,000 tons are wasted in smoke and soot. It is sought to replace this use of soft coals by coalite. The statements made in the prospectus are attested to by several British experts.

In connection with these statements it is interesting to note some statements made by Mr. N. H. Humphreys,* of Salisbury, England.

The Gas, Light and Coke Co. are putting a similar fuel on the market under the title of "Carbo," and a leading gas engineer has stated that there is no patent on coalite, but that any gas company can make it if it suits their purpose to do so. The questions of particular interest from our point of view are, assuming coalite to be a practical success: what is to be done with the excess of gas and what is going to be the effect on the coke trade? As regards the liquid products, we shall be interested in seeing if they can be made to yield a better return than gas tar. We may also consider the effect of a large coalite demand on the coal market. The qualities of coal described as "cheap" occupy that position because it is difficult to find a demand for them and because they are really a kind of residual from screened coal. A big drop in the demand for better class coal, and at the same time a large increase in the demand for cheap coal, cannot but have a decided effect on market conditions. Collieries are not run for the production of small or slack alone, but depend mainly upon the very demand which coalite aims to displace. Gas is all very well as a primary, but might prove awkward to deal with as a residual product. This difficulty has already risen in connection with coke ovens in Germany, where an auxiliary gas works has proved a necessary addition to the coke oven plant. Gas cannot be stored to any extent, and the demand fluctuates with the temperature and the seasons, and it might be a difficult matter to get the demand for the primary product to keep pace with it.

The only apparent difference between coalite and the coke made in iron retorts in a small village or private gas works, when carbonizing temperatures in the neighborhood of that claimed for coalite are not an uncommon thing, is that no water is used for its extinction. And this suggests the idea, whether many if not all the advantages claimed for coalite, could not be obtained by smothering ordinary coke instead of drenching it. The red-hot charges might be drawn into receptacles capable of being closed, and the cooling facilitated by the application of water to the exterior. In the laboratory it is usual to draw a charge in this way, or to place the charge to be tested in a sheet iron box fitting the retort, the charge being pulled out on to a slab flush with the mouthpiece and instantly covered from the air. The object of this arrangement is to avoid loss of coke either by spillage or combustion after drawing, but the point with which we are now concerned is that the coke so prepared is as superior to ordinary coke as freshly wrought coal is to a sample that has been exposed in an open yard for several months. Why should it not be possible to secure coalite without sacrificing half the yield of gas?

*American Gas Light Journal, issue of Sept. 2, 1907.

A NEW TYPE OF AUTOMATIC STOKER.

There have been up to the present three general types of automatic stokers for steam boilers. These stokers may be called "over-feed," "under-feed" and "chain-grate." A stoker has been recently developed, which establishes a new type which may be designated as the "automatic-shovel" or "strewing."

This new type is known as the Caldwell Mechanical Shovel and by its use it is attempted to obtain the best results of hand firing, where light charges of coal are well scattered at short intervals over the bed of incandescent fuel. How this action is attained is seen by reference to Fig. 1. By the forward movement of the reciprocating ram "A," a small charge of coal (normally about 14 cu. ins. or 0.6 lb.) is deposited, in the pocket of the casting "D," and in front of the shovel blade "C." This blade is keyed to a shaft as shown, and is swung back, by a cam and tappet arrangement, to a release-point. A heavy spiral spring, "E," now comes into action and the shovel blade is swung forward with a quick movement which throws the coal to a predetermined place on the grate. By a proper mechanism the tension of the spring, "E," is regularly increased at each stroke of the shovel blade up to a certain maximum point. By this scheme the coal is distributed over the entire grate area and is not dumped in one spot. The shovel mechanism is so arranged that the strongest cast of the blade is followed by the weakest and the strewing of coal is always progressive from front to back.

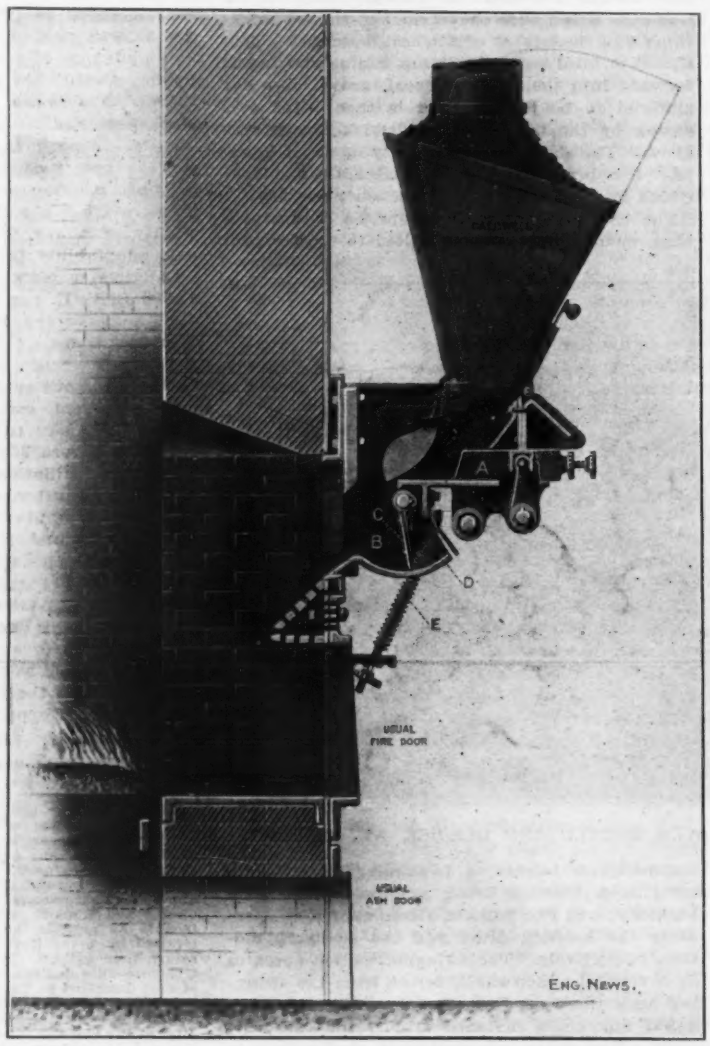


FIG. 1. SECTION OF CALDWELL MECHANICAL SHOVEL.

In all other types of automatic stokers, the movable grate is a part of the stoker outfit. On account of continuous motion, the grate bars are exposed to a higher temperature than in a hand fired boiler where a protecting layer of ash is more apt to come between grate bars and incandescent fuel. Any grate trouble in the other forms of stokers has often been attributed to the stoker alone. In the Caldwell Mechanical Shovel the grate and stoker are distinct. The grates may be of any pattern found adapted to the coal to be burned. The grates may be supplied by any parties and may be changed as often as desired without interfering with the stoker.

It will be observed that so far this new stoker has no provision for the handling of ashes, either from the grate or from the pit. This refuse may be disposed of as in hand firing or by any automatic way found desirable. With very poor coal and plain grates, the clinker and ash may be drawn, if necessary, through the regular fire doors, which are not obstructed by the Caldwell Mechanical Shovel. Common dumping grates may be actuated as usual in hand-fired boilers, allowing the fire to be cleaned several times a day. The recommended method of freeing the bed of burning fuel from excess of ashes employs common shaking-grates which are operated by hand at stated intervals, or as the boiler-room attendants may judge necessary. The grates may be continuously shaken by an attachment to the shovel mechanism if this is judged desirable. The ashes may be removed from the pit or sub-cellar by any means desired.

The advantages claimed for this new type of stoker, aside from those outlined above, may be summarized in the following brief sentences. Each square inch of available grate area is covered with incandescent fuel, there being no green fuel at the front nor clinkers at the rear of the grate. The fuel is handled raw and cool. Any quality of coal may be burned on proper grate bars. The mechanical shovel gives improved "hand firing" with the saving resulting from automatic operation and closed fire doors.

This shovel-stoker is manufactured by the Sarco Fuel Saving and Engineering Co., West Street Building, New York City. Mr. H. Sanders is President, Mr. C. O. Mailloux, Mem. Am. Inst. E. E., Vice-President, and Mr. J. A. Caldwell, General Manager.

A DRAWBRIDGE ACCIDENT at Chicago on Sept. 10 put the bridge out of use (except for pedestrians) for almost an entire day. The steamer "E. M. Peck," with 2,500 tons of iron ore, was being towed into the south channel at the Wells St. swing bridge when it got beyond control of the single tug that was trying to handle it and struck the bridge abutment a heavy blow. The steamer was going westward, with the current, and the channel between the abutment and the center pier is only about 60 ft. wide. The abutment was shifted several inches and a gap of about 3 ins. opened across the sidewalk of the approach, while the paving was broken and bulged up by the shock. Owing to the damage and distortion neither the surface cars nor the trains of the Northwestern Elevated Ry. (on the upper deck) could cross the structure until late in the afternoon. A somewhat similar but less serious accident occurred a few weeks ago at the Clark St. swing bridge, when a steamer struck the abutment and tore away the sidewalk and railing.

THE PRESENT CONDITION OF THE BATTERY TUNNEL UNDER THE EAST RIVER.*

The conditions existing to retard the opening of the Battery tunnels under the East River at New York, through which the present Manhattan subway is to be continued into Brooklyn, have been a source of much worriment to the metropolitan daily press and especially to the residents of Brooklyn, who have been waiting for nearly a year since the promised completion of these tubes. On account of this great public interest and also to thoroughly inform themselves, the recently organized Public Utilities Commission called upon Mr. George S. Rice, Chief Engineer of the tunnel for a report detailing the present status of the work. We reprint below portions of this report:

This East River tunnel contract is a portion of the contract made by the Board of Rapid Transit Railroad Commissioners with the Rapid Transit Subway Construction Company, for an extension from the first rapid transit railroad from the post-office to the Long Island Railroad station in Brooklyn. This contract was sublet in three sections—the first, the subway in Manhattan from the post-office to Battery Park; the second, the tunnel extending from Battery Park to the Borough Hall in Brooklyn; and the third, from the Borough Hall to the Long Island Railroad station at the junction of Flatbush and Atlantic Aves.

The first section, in Manhattan, has been completed for a considerable time, and is in operation.

The third section, in Brooklyn, has been largely modified and is well advanced towards completion.

The second section, the tunnel under the East River, the completion of which has been delayed, is now in a fair way of being put in operation within a period of two months.

The condition of the work on the tunnel contract is practically as follows:

This tunnel is a double tunnel, so designed that trains will run in separate tubes in going to and from Brooklyn. The Manhattan approach, which begins at Battery Park and extends to the shaft situated at the lower end of the Park, is practically finished, except for the laying of a short section of track in the north tube. The second section in Manhattan, which has been excavated in rock, extends from the shaft above mentioned in Battery Park to the end of the rock formation almost in the middle of the East River. This section has been lined with concrete, including the benches, except for a short stretch in the vicinity of the lowest "sump" near the east end of the rock section.

In the south tube of this Manhattan section in rock, the concrete track bed and the cast-iron drain pipes are in place for the same distance as the concrete lining. Over the same stretch in this tube the ties and some rails have been distributed.

The midriver section, which extends from the end of the rock formation in Manhattan to the cross-connection for the sump in the rock reef located on the Brooklyn side of the river, includes about 500 ft. where the foundation of the tube is in fine sand. In these stretches there are 17 concrete pile bents under the north tube, and 15 under the south tube, spaced about 30 ft. apart, and extending to hard material at depths ranging from 5 to 60 ft. The calking in this section is in good condition. The reinforced-concrete bottom and the drain pipes are in place over the whole extent of the piled stretch in the north tube, and over the westerly half of it in the south tube. About 300 ft. of bench have been placed in the north tube, and about 100 ft. in the south tube. No roof concrete lining has been placed in this section in either tube.

In the section of the river on the Brooklyn side extending from the reef to the vicinity of Furman St. in Brooklyn is included a stretch of about 700 ft. in each tube where the foundation is in fine sand and clay. In these stretches there are 15 concrete pile bents under the north tube, and 14 under the south tube, spaced about 50 ft. apart, and extending to hard material at depths ranging from 3 to 75 ft. In the north tube the calking is in good condition, and in the south tube the calking was tested recently by reducing the air pressure, and the test has proved satisfactory. The reinforced-concrete bottom and drains have been placed over the whole extent of the piled stretch in the north tube. Over the same distance the concrete bench is in place, except for a stretch of about 100 ft. near the middle.

In the Brooklyn land section, which extends from the shafts in Furman St. to the end of the section at Clinton St., both tubes have been lined with concrete, including the benches and track foundation concrete, and drain pipes embedded for the whole of this stretch, except for a short distance east of the shaft in the north tube. The tubes are in good condition.

The excavation for the ventilating shaft on the Manhattan side of the tunnel at South Ferry is complete, and

*See previous articles in Engineering News, May 31, 1906, p. 611-12; June 27, 1907, p. 717-18.

concrete has been placed in the sides and bottom preparatory to the waterproofing. The excavation for the Joralemon St. shaft just east of Willow Place is complete. This shaft is being built in caisson under compressed air. The waterproofing of the bottom is practically finished, some concrete bottom is in place, and considerable of the steel work for the lower portion is set up.

There are three sumps besides those which are to be at the ventilating shafts. Two of these are located in the rock section on the Manhattan side, and one in the Brooklyn reef. The westerly Manhattan sump is finished, except for installing the pumps. The easterly Manhattan sump is excavated, but is not yet lined with concrete. The Brooklyn sump in the rock reef is now in progress of excavation.

Generally speaking, the tubes are practically complete and ready for track laying and the installation of the signal system, except for the section from the middle of the river to the Brooklyn shore.

In this particular stretch of the tunnel all kinds of work is rapidly being done to finish the tubes. The reconstruction work is entirely finished, the piles are all in, and the lining has been made watertight.

The principal work now remaining to be done before laying track, consists in lining the roof and sides of the tunnel with reinforced-concrete over the two sections where the bottom is in fine sand, and finishing the ventilating shaft in Brooklyn.

So much has been said lately in connection with the tunnel work that I think this an opportune time to make some statements in reference to this work. The public evidently have a wrong impression of the condition of the tunnel, which impression is due principally to the delay which has been occasioned in this part of Contract No. 2.

In the subletting of Contract No. 2, excellent selections were made of sub-contractors, with the exception of the tunnel portion. The contract was sublet to the New York Tunnel Company; the influential factor of the company being Andrew Onderdonk, who had assumed charge of the work when in ill health and afterwards died. Such an occurrence naturally interfered with the carrying on of the work, and about a year and a half ago the New York Tunnel Company was confronted with troubles which have since resulted in their not meeting their obligations; liens were placed upon the payments due them, and several months ago the company went into bankruptcy. The original contractor, however, advanced the necessary funds, and the work has progressed slowly, due to unfavorable conditions.

The contractor for this work, as on the first contract, has spared no expense in order to make the work complete in all its parts, and in many cases assuming expenses which were not strictly included in the contract in order to faithfully carry out the work.

The contract as originally drawn contemplated the construction of a double-tube tunnel about 15½ ft. in diameter. The details of the interior finish of this work were not determined at the time of letting the contract, as at that time the exact conditions which would be necessary for the proper operation of the road were not known. Cars had not been designed, nor had the form of contract for them been decided upon.

For over a year the engineers of the Rapid Transit Subway Construction Company were in consultation with the engineers of the Rapid Transit Board in perfecting the details for this particular work, and plans for the construction of the interior of the tubes have been carefully designed. These plans contemplate the building of a concrete lining over the entire length of the tunnel in the bottom and sides and top of the tubes.

The section of tunnel as originally designed was made large, so that in case of changes of alinement and variation in the grade the operation of the trains would not be seriously affected. On account of the methods pursued by the sub-contractor, the extent of the variation provided for was exceeded, and those portions of the tube in sand have been reconstructed in parts, so that a clearance of 4 ins., as a minimum, can always be maintained throughout the work. In almost all cases this clearance exceeds 4 ins., but the minimum was made to conform to the clearance which exists all along the rapid transit subway in Manhattan, of which this work has been made a part.

For some distance under the tube the contractor deemed it wise to construct piles, as hereinbefore described. These piles in my judgment, and in the judgment of most of those who have looked into the matter, are unnecessary, but have been constructed by the contractor merely for the sake of an additional safeguard. If the tube is made watertight there is no danger of its getting out of grade. The tube has been constructed of many thousand different sections which have been calked under air pressure, and which, before the work is completed, are made absolutely tight. The calking of these joints has been made under varying pressures, and after the construction of the tube the pressures are greatly reduced, bringing out any defects which may be found in calking. When these defects are found they are immediately made good. At the present time the entire length of the tunnel is without any air pressure, except for a short distance in the south tube, near the Brooklyn shore, where there is comparatively little pressure, and this is to be taken off within a very short time. When this is done, all parts of the work can be rapidly finished, as it will then be possible to put men into this work without air pressure, which, to many, is very objectionable.

The work has been well executed, but like all tunnel work where the conditions are questionable, the time for completion has been extended beyond the contract time. Early in the year I stated that I thought it would be some time in October before the tunnel would be ready for the operation of trains. Since that time conditions have been changed somewhat by the introduction of plans for reinforcing and supporting the tubes, and while it is still my belief that it will be possible to start operation of cars in October in at least one of the tubes, it now seems more likely that this will not take place until later, probably some time in November.

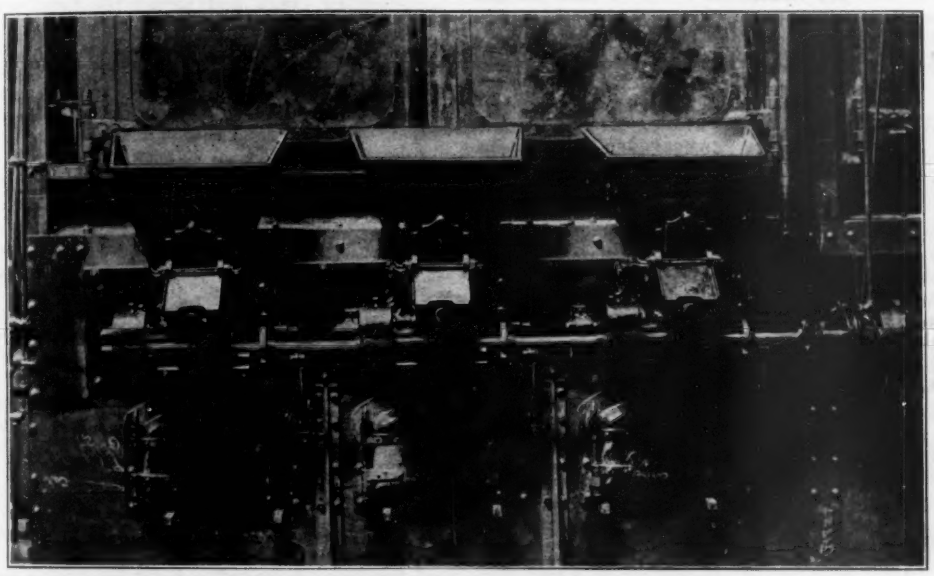


FIG. 2. FRONT VIEW OF CALDWELL MECHANICAL SHOVEL; PART OF INSTALLATION OF INTERNATIONAL PAPER CO., PALMER'S FALLS, N. Y.

SEWAGE DISPOSAL FOR THE CALUMET DISTRICT is to be studied for the Sanitary District of Chicago by Hering & Fuller, of New York City. A report on this subject, made to the International Waterways Commission by the same engineers, was published in abstract in our issue of Jan. 31, 1907. The district trustees have been preparing a drainage canal from the Calumet District to the existing Chicago drainage canal, at an estimated cost of $12,000,000. The report by Hering & Fuller, already mentioned, showed that the proposed Calumet Canal would not protect Lake Michigan at all times and contained figures indicating that sewage purification would be cheaper than diversion. The employment of the same engineers by the Sanitary District appears to be, in part, a result of local opposition to the canal plan, at least pending more detailed study of all the questions involved.

HYDRAULIC ENGINEERING AT THE UNIVERSITY OF WISCONSIN.*

By DANIEL W. MEAD, M. Am. Soc. C. E.†

The last twenty years has witnessed a decided increase in the relative importance of the various problems of hydraulic engineering. The development of electrical generation and transmission has rendered many of the potential water powers of the country of importance, and made it possible to develop and transmit to centers of population and manufacturing, hydraulic energy which previous to this generation has been of little practical value on account of the distance of such powers from a profitable market. The design and construction of such works has become an important feature among modern engineering works.

Prior to 1904 the writer had been engaged for twenty years in active practice in civil engineering, much of the time in hydraulic work. He had given no particular attention to the question of technical education, but had decided views as to the desirability of a considerable change in such education as applied to the line of work in which he was engaged. In that year he accepted the chair in hydraulic and sanitary engineering in the University of Wisconsin, with the privilege of continuing his professional practice. It was understood that he should develop the department of hydraulic engineering on the lines of his personal ideas, and that such development should be carried to the extent that the importance of the department or the demand for such development at the university would warrant. It was also understood that opportunities would be afforded for research work along hydraulic lines, the importance and necessity of which the writer appreciated from his own studies, experience and investigations.

Three years have elapsed since the writer began his work at the University of Wisconsin. Many of his early ideas have been modified by his experience in the educational field. He began this work with a fairly clear appreciation of the difficulties that confronted him. He recognized the possible errors to which an instructor who came, without previous experience, from a field of practice into educational lines would be liable, that such an instructor was liable to overestimate the real educational value of certain lines of information which might seem from his practical experience of importance, and to underestimate the real educational value of much that was taught in technical institutions which might seem to him of little practical value or importance to the professional engineer. He believed also that a theoretical education, having no direct bearing on the practical problems of the engineer, while it might be of value in an educational way, would better be replaced by technical studies which had a direct or indirect relation to the actual problems of the engineer, and which could be made of equal importance from the purely educational view.

Innovations have been introduced slowly and only after careful consideration and discussion with the dean and with other members of the engineering faculty teaching those subjects dependent directly or indirectly on the subject of hydraulics. Both the instructional method of presenting most of the subjects taught and the subjects themselves have been changed considerably from the curriculum ordinarily offered by technical schools. Recognizing the possibilities of serious errors resulting from a false point of view, and the value of establishing correct principles as a foundation for the technical education of the young engineer, the writer desires to call the attention of both practicing engineers and of those engaged in instructional work in hydraulic subjects, to the changes made and the methods pursued in this department in the University of Wisconsin.

No independent department of hydraulic engineering existed at the University prior to the writer's appointment. The subjects taught were divided among various departments. Theoretical hydraulics was taught by the Department of Mechanics as a part of the course in theoretical mechanics; water supply, sewerage and sewage disposal were taught by a member of the faculty, who also taught structural engineering. Hydraulic machinery included only a theoretical discussion of the hydraulic turbine and the laws of flow through its guide passages and buckets; hydraulic laboratory work was taught in connection with work in the steam laboratory. These subjects were differentiated and brought into the Department of Hydraulic and Sanitary Engineering.

Theoretical Hydraulics, as formerly taught in the University of Wisconsin, and (as far as the writer is informed) in all other technical institutions, consisted solely of a theoretical discussion of hydraulic principles, practically separate and distinct from any demonstration in the laboratory or other illustrative work. The laboratory work was a thing apart, and was not carried on as a part of the theoretical course. It has, indeed, been found impossible at the university to carry

*Abstract of a paper read before the Western Society of Engineers, Chicago, Sept. 4.

†Consulting Engineer, Chicago; and Professor of Hydraulic and Sanitary Engineering at the University of Wisconsin, Madison, Wis.

on the laboratory work in direct connection with the work of the theoretical course. This is largely due to the fact that every laboratory is limited both in size and equipment; that the time available for laboratory work is also limited; and that it is therefore impossible for the students each to perform the experiments at the same time they are studying the text.

This theoretical work given entirely or partially apart from any illustrative experimental or laboratory work has been very unsatisfactory in its results. Students do not, as a rule, become interested in the subjects which they with difficulty understand, and which are illustrated only by such cuts and pictures as can be made and reproduced in the text-book. The students usually fail to grasp the full meaning of the theory or to appreciate its application, and to a large percentage the course seemed of little direct value, except fundamentally, or until they enter into active practice and begin to realize from their own actual experience the meaning and bearing of the subject.

No subject can be so thoroughly well taught that it will become fully the mental property of the student until he has had the opportunity of putting it into active use in his practice in many places and at many times. He then begins to fully realize the meaning and importance of a subject from his own practical experience. It has, however, appeared to the writer that it would be possible to illustrate and demonstrate the ideas, conceptions and theories of hydraulics, which it is desired to convey to the student by class-room experiments, in such a way that he could better appreciate the meaning and intent of these theories and conceptions, and be more ready and able to apply them correctly to his practical work when such work comes to hand. The theory and the facts in the case will be seen to accord, and he will receive not only a mental but an optical demonstration. His interest will be aroused, and that which was before a dry and uninteresting subject will become attractive. The result, it is believed, will be of importance not only in the teaching of the fundamental principles of hydraulics, but also in the laboratory work which will follow.

There has been introduced into the curriculum the subject of hydrology, not hitherto taught in the University of Wisconsin, or (as far as the writer knows) at any other institution. The most prolific source of failure in hydraulic installation, hydraulic problems, or schemes in which hydraulic problems are involved, is the lack of fundamental knowledge of many of the principles that are included under the title of hydrology. This, in its broadest sense, treats of the properties, laws and phenomena of water; of its physical, chemical, and physiological relations; of its distribution and occurrence over the earth's surface and within the geological strata; and of its sanitary, agricultural and commercial relations. In presenting this subject to engineering students such relations as bear more specifically on the work of the engineer are discussed and considered.

A study of this subject should precede all advanced work in hydraulic engineering. At present it is required only of the students in civil engineering, and prior to their consideration of the subject of water supply, drainage, irrigation, and of sewerage and sewage disposal. The students in mechanical and electrical engineering who are required to take up the course in water power, are not required to take hydrology as a pre-requisite to the water-power study. In consequence, those elements of this subject which bear more specifically on the subject of water power are discussed in the water power class. It is the writer's belief, however, that hydrology should be a required subject for all engineering students, just as much as the subject of theoretical hydraulics. The other subjects included at the present time in the department of hydraulic and sanitary engineering are, public water supply, drainage, sewerage and irrigation (considered as a single subject), water power, hydraulic machinery, and rivers and canals. In all of these subjects an attempt is made not only to develop the theory, but also to show the application.

Outside of the subject of theoretical hydraulics, perhaps the greatest departure that has been made from past practice among technical schools is in the instruction on the subject of hydraulic machinery. Text-books on hydraulic machinery are written principally from the standpoint of the designer, or the man who is expected to undertake the construction of this class of machinery. The theory of the machine and the theoretical effect of modification in form and design are discussed, and the practical results of its actual use are not considered. Of the students who pass through our educational institutions a very small percentage give their time and attention to the manufacture of hydraulic machinery. Almost all of them, however, will use machinery of this kind to a greater or less extent, and are therefore interested in its selection, installation, operation and maintenance. It is from this standpoint that an attempt is made to consider the subject at the University of Wisconsin.

The engineer who is called upon to select and install this class of machinery for his client or employer is necessarily and particularly interested in the details of construction so far as they will affect the efficiency and operation of the machine. He needs specific information concerning the general features of all machines with which he must be necessarily acquainted in order to intelligently and satisfactorily accomplish his purpose. It is this conception of hydraulic machinery which the writer is endeavoring to embody in the course in hydraulic machinery. It must not be understood that an attempt is being made to introduce a large amount of disconnected information which, while important to the practicing engineer, does not constitute the foundation for a proper technical education. An attempt is made to impart the necessary theoretical basis which will allow of correct deduction in the subject considered, and to furnish the fundamental basis on which the principle of the selection of machinery must depend. Also to develop those principles in machine construction which it is not only important, but essential, for every practicing engineer to know in order that his work shall be done to advantage. In all these subjects an attempt is also made to assure a knowledge of the literature of the subject so as to make it fully available for future study and research, to impress the necessity of careful and detailed study of each particular problem by itself, and to induce a recognition of the theoretical principles which must underlie the subject and which are necessary for its proper consideration and for its successful treatment.

The hydraulic research work has been under the immediate charge of Mr. C. B. Stewart. The theoretical hydraulics and instructional laboratory work has been in the immediate charge of Prof. G. J. Davis, Jr., and Mr. L. F. Harza. The advanced laboratory* and thesis work is supervised by Prof. Davis and the writer.

CLEANING STEELWORK BY SAND BLAST AND PAINTING BY COMPRESSED AIR.

By DE WITT C WEBB.†

At the U. S. Naval Station, Key West, Fla., are two large steel coal sheds whose vertical side walls are composed of ¼-in. steel plates, and are from 16 to 20 ft. high. The action of heat and impurities in the coal combined with that of the large quantities of salt water used for extinguishing spontaneous combustion fires rapidly corrodes the interior steelwork and necessitates its thorough cleaning and painting every time the sheds are emptied.

Shortly after the writer was detailed to this station his attention was attracted to this subject, and he concluded that the use of a portable sand blast cleaning and spray painting outfit would be very advantageous in point of efficiency and time as well as cost. This idea meeting with the approval of the Bureau of Yards and Docks, the following outfit was purchased at a cost of $2,000, delivered at the Naval Station:

1 horizontal gasoline engine, about 20 HP.
1 air compressor, capacity about 90 ft. of free air per min. compressed to a pressure of 30 lbs. per sq. in. in one stage, belt connected to engine.
1 rotary circulating pump, belt connected to engine.
1 galvanized steel water tank.
1 air receiver, 18 × 54 ins.
(The above apparatus was all mounted on a steel framed wagon with wooden housing.)
2 sand blast machines, capacity 2 cu. ft. of sand each.
2 paint spraying machines, one a hand machine of ⅔-gal. capacity for one operator, the other of 10 gals. capacity for two operators.
100 lin. ft. of sand blast hose.
200 lin. ft. of pneumatic hose for sand blast machines.
400 lin. ft. of pneumatic hose for painting machines.
100 lin. ft. of air and paint hose for painting machines.
4 khaki helmets, with mica-covered openings for the eyes.
200 lin. ft. of 2-in. galvanized iron pipe.

Previously to the delivery of this material, shed "A" had been emptied of coal and the work of cleaning the inside surface of the wall plates was begun by hand in the usual manner. About 7,000 sq. ft. out of a total of 9,000 were thus cleaned at a cost of slightly over 4 cts. per sq. ft. On the arrival of the sand blast outfit the hand work was stopped and after a short preliminary trial the machine cleaning was started. The work proceeded rather slowly until the men became accustomed to it, yet the 2,000 sq. ft. of previously untouched surface was thoroughly cleaned and the 7,000 sq. ft. of hand cleaning was all gone over and much improved at a total cost for labor of $97.68 and for gasoline of $16.13. The force consisted of the following:

	Per day.
1 engine tender	$ 1.76
1 helper (in charge of the work and tending machines)	3.04
2 laborers on machines, at $1.76 each	3.52
1 laborer drying sand, filling machines, etc.	1.76
Total	$10.56

From 10 to 15 gals. of gasoline were required per day of 8 hrs. (costing 19 cts. per gal. here).

For the painting the coal tar paint originated by Civil Engineer A. C. Cunningham, U. S. N., was used (see Eng. News, July 12, 1906). This paint was prepared with the following proportions (by volume): coal tar, 4 parts; kerosene oil, 1; Portland cement, 1.

The Portland cement was first well stirred into the kerosene oil, forming a creamy mixture; this mixture was then carefully stirred into the coal tar. It was freshly mixed as needed and kept well stirred. The cost of this paint at Key West is about 15 cts. per gal. It was found not to be so well suited to the pneumatic spraying machine as oil paint, but worked very well; though, of course, the machine used considerably more than hand work. In all, on this shed, 64½ gals. of paint were required for 9,000 sq. ft., or about 1 gal. to 140 sq. ft. The force used in painting was the same as in cleaning, with the addition of a laborer, who followed up the painters with a long-handled brush and spread the paint uniformly. The cost of painting this shed was: for labor, $28.16; for gasoline, $3.80.

On shed "B" a total area of 12,500 sq. ft. was cleaned and painted. This steelwork was covered with a scale nearly ⅛-in. thick and was deeply pitted. The scale and rust was very tough, and extremely hard to remove. On this work it was found economical to keep men ahead of the sand blast with sledges, loosening and shaking off as much of the scale as possible. The labor cost of the whole work on this shed (cleaning and painting) was $460, including the cost of moving, setting up and removing. Gasoline cost $81. A total of 86 gals. of coal tar paint was used, covering about 145 sq. ft. per gal. Total cost of labor, fuel and paint, $553.90, or 4.4 cts. per sq. ft. It is impossible to separate the cost of cleaning and painting on this work, as only small areas were painted at one time, the painting being done by one operator, the other working the sand blast. This was done in order to expose the cleaned steel to the atmosphere for as short a time as possible.

A fine silica sand was used, that being the only kind available except coral sand, which was tried, but found to be too soft. A coarser sand would probably have been more effective. The sand was all saved, dried, and re-used several times. About ½ cu. yd. of fresh sand was required daily. The sand must be kept perfectly dry for this purpose, and there are patented sand driers manufactured. Very good results were obtained on this work, however, by the use of a sheet of boiler plate set up on bricks with a wood fire underneath.

No claims are made of extreme economy in the above work. The extremely thick and tough scale to be removed, the high fuel and labor cost of compressing air simply for this work, and (probably) the lack of the best kind of sand for the purpose, combined to make the work expensive. With these drawbacks it was, however, considerably cheaper than hand work, and what is more important, the cleaning was much more effective and thorough than could possibly have been done by hand.

*An illustrated description of the laboratory appeared in Engineering News, April 19, 1906, p. 444.
†Civil Engineer, U. S. Navy, Key West, Fla.

A RECORD FOR PIPE LAYING, it is believed by those directly concerned, has been recently made in connection with the contract for the Massapequa Infiltration Gallery, Department of Water Supply, Brooklyn. During the 24 working days of August (10 hrs. each), a double line of 33-in. vitrified pipe was laid in a trench 10½ ft. wide, 27½ ft. deep, and 453 ft. in length, or a total of 906 ft. of single pipe. The work was done with a suspension cableway by means of which 6,000 buckets of earth were handled and 352 lengths of pipe were lowered into place. During the work 1,100 ft. of 16-ft. sheathing plank were pulled from the ground. The contractor for this work was Mr. M. J. Dady, 350 Fulton St., Brooklyn. Mr. Jos. Rufino acted as foreman. Mr. Calvin M. Depew was engineer for the work, and to him we are indebted for the information given.

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Entered at the New York Post-Office as Second-Class Matter.

The arrival at New York last week of the "Lusitania," the largest and fastest ocean steamship ever built, completing her maiden voyage across the Atlantic, concentrates public attention anew upon the Atlantic speed record. The "Lusitania" and her sister ship the "Mauretania," which is now nearing completion, are indeed a great triumph of marine architecture and marine engineering. They were built, as our readers will recall, as the result of a joint agreement between the Cunard Company and the British Government, by which the latter paid a large part of the cost of constructing the two great vessels. The British public was willing to pay its share as a matter of national pride in recapturing from Germany the speed record for the transatlantic voyage. The Cunard Company was willing to stand its part because of the advertising value in the achievement of breaking the Atlantic record; and the further benefits from the ownership of vessels which excel all rivals in size as well as speed.

We deem it well to make these facts clear; because the general public has a most exaggerated idea of the importance of breaking the transatlantic record. Important it doubtless is, from a sporting point of view; but its actual value to the traveling public or to the shipping companies which are carrying on their business to earn profits is vastly overestimated. The "Lusitania," for example, made an average speed of 23 knots on her maiden passage and may be expected to reach perhaps 24½ knots for the whole voyage in favorable weather later. That would mean a passage from Daunt's Rock to Sandy Hook in 4 days 17½ hours. To this is to be added a night's run from Daunt's Rock to Liverpool and the time of passage from Sandy Hook to the pier on the North River, making nearly 5½ days as the actual length of the voyage. Remembering that landing at either end is effected only during daylight hours, it is seen that actually the passenger on this fastest ocean greyhound, driven at her best pace, must count on spending six days in the voyage from port to port.

Contrast now with this the experience of a passenger on a vessel of more moderate speed, say 18 knots. Since resistance to propulsion varies as the cube of the speed, the power required for an 18-knot vessel will be to that necessary for a 24-knot vessel of the same tonnage and lines as 4,032 is to 13,824, or as 1 is to 3.43. Actually the difference is apt to be considerably greater on account of the lessened efficiency of the screw propellers of the high speed vessel; and if the "Lusitania's" four giant turbines develop 65,000 HP. to give her a 24-knot speed, it is likely that engines of no more than 17,000 to 18,000 HP. would drive her at 18 knots. An 18-knot vessel can make the transatlantic passage in six days and ten hours and with favorable conditions can land her passengers at their destination on the same day of the week that they sailed from the other side of the ocean.

In order to cut off an extra day or day and a half from the transatlantic voyage, the steamship company must not only go to the expense of a huge engine and boiler capacity, of the coal required to operate and of the necessary engine and boiler room staff, but what is of much more importance, it must sacrifice the cargo carrying space which the engines and boilers and coal displace.

The passenger vessels that earn profits in the transatlantic service are the seven-day and eight-day and nine-day boats, which carry huge cargoes of freight and nearly as large a passenger list as the crack greyhounds besides. It is these vessels which have to pay the cost of running the record-breakers, for the passengers on the fast express steamers will not pay any excess fare of any consequence for the high speed at which they are transported across the seas. Passage on the huge White Star seven-day boats, for example, sells as readily and at as good prices as passage on the six-day and five-day boats. To only a very small percentage of transatlantic travelers is the saving of a day or two in length of voyage of any considerable importance. Many choose the large freight-carrying steamers in preference, not only because the longer voyage is to many an advantage instead of an objection, but because the huge freight carriers are steadier in rough weather, and are less subject to vibration than the vessels with high-speed engines and propellers.

An additional handicap under which the greyhound labors is that transatlantic passenger travel varies enormously with the season. The boats run full for only a small part of the year, and have to lie idle in port a considerable part of the time. The big freight carriers, however, can go on earning profits from cargo the year round.

The paper in this issue by Mr. Henry S. Prichard on the Proportioning of Railway Bridge Members is of especial interest at this time, when the attention of engineers is drawn to this particular subject by the momentous disaster at Quebec. Notwithstanding the fact that the Quebec bridge failed under comparatively moderate load, so that the disaster cannot well be ascribed to the use of high-unit stresses in proportioning, the whole design of the great structure is bound to be subjected to keen analysis and criticism by engineers. Information necessary for such analysis was afforded by the detailed drawings and data published in our last issue, and our correspondence department this week indicates something of the extent to which engineers are studying the subject.

Since our last issue the Coroner's jury, at Quebec, has concluded its work without shedding any new light on the circumstances of the accident, and the government investigating commission of engineers has begun its sessions. Naturally, a chief point of importance in these official investigations is to determine the degree of culpability of various individuals for the failure to stop work on the erection in time to save the lives of the employees. To this end, the commission has been trying to ascertain just how much evidence the bridge gave of its overstrained condition prior to collapse.

It is at this point that the investigation becomes of very great importance to the engineering profession. How much warning does a huge bridge structure give of overloading before it gives way? The first press reports of the Quebec collapse were to the effect that the bridge had gone down absolutely without warning. Shortly afterward came the discovery that a bend in chord member A9L had been discovered three days before the collapse. It is important to know in detail exactly what was the condition of the latticing when this bend was examined. We are told that testing with a hammer showed at least one loose rivet, and that the lattice bars "sounded high" when tapped; but it would be interesting to learn whether there were no other indications that might have more effectively warned those in charge of immediate danger.

Again, were there any other signs of overloading on other parts of the structure? Inquiry of the engineers on this point has yielded nothing; but information from other sources arouses suspicions that there were other places than chord A9L which were showing signs of crippling, and showing it nearly three weeks before the collapse occurred. In testifying before the commission last week, one of the workmen reported that one of the chord members of the cantilever arm near the tower was giving evidence of trouble, so that he and other workmen had examined it. He speaks of lattice angles which had started to buckle, and of chord ribs which were bent in or out from a straight line. It is impossible from such reports of this testimony as are now at hand to report it in detail; and allowance must be made for the fact that it comes from a workman who is naturally desirous of aiding his fellow-workmen in possible suits for damages. Nevertheless, the possibility that other lower chord members than A9L were showing signs of distress ought to be and doubtless will be sifted to the bottom. Engineers have believed that it was possible for experts to determine by careful inspection of a structure whether evidences of overloading were present. If this is not the case, and a huge piece of steel like the Quebec bridge can appear in perfect condition and yet collapse under static loads without warning it is cause for great uneasiness among engineers. The actual facts in this matter must be determined, no matter what its bearing may be on the responsibility of individuals.

Designers and managers of steel railway bridges, elevated railways, and the like, should study a suggestive statement made by the inventor of a steel tie recently. Speaking of the many advantageous features of steel ties, he incidentally mentions this one:

> The dust of the road settling on the grease dropping from the [axle-] boxes makes a substance which deadens the noise of the train.

The remarkable prevalence of the idea that ballast-filled solid floors, which are expensive, are the cheapest available noise-deadening device for railway bridges seems to be due entirely to ignorance of the magic effect of smearing an innocuous paste over the steelwork of the bridge floor. The discoverer of the new phenomenon deserves censure for hiding the discovery in the columns of a country newspaper. We trust the present notice will give it the wider publicity it merits.

EVAPORATION LOSSES IN IRRIGATION.

The vast areas of land in the western part of the United States that lack only water to make them as productive as any land on the face of the globe render of vital importance any practicable means for conserving the available water supplies of that section of the country. As those who have looked into the subject are well aware, the potentially fertile lands in our regions of deficient rainfall are many times in excess of the area that could be irrigated if all the water falling in those sections as rain could be got to the land. For obvious reasons, only a portion of the rainfall can ever be brought to land under irrigation, which renders it all the greater pity that so much of the water supplied to irrigators is wasted by them. The engineer, working some-

times in cooperation with land owners and sometimes, perhaps, with land owners antagonistic to him, has done much to conserve the irrigating waters of the West. By improved methods of water distribution—including lining of canals to prevent seepage losses, and the distribution of water by pipes where the intensity of cultivation warranted the expense—the engineer has reduced or made it possible to reduce to a minimum the loss of water up to the time that it is delivered to the farmer or irrigator for application to the roots of his crops. He has even gone farther than this, and collected valuable data on the duty of water for various crops, and shown how the farmers have often demanded and been given more water than they could possibly use to advantage. Many of the studies of water conservation for irrigating purposes have been made more or less at random by different engineers, or if not so made the results are at least scattered, and thus not always readily available nor well arranged for purposes of comparison. For the last ten years or so, however, the U. S. Department of Agriculture, Office of Experiment Stations, through the irrigation and drainage investigations carried on by Mr. Elwood Mead, M. Am. Soc. C. E., and others, has collected and arranged many valuable data on the use and abuse of water in irrigation, and in addition has contributed no small amount of information by its own original work. Elsewhere in this issue we publish an interesting and instructive article by Mr. Samuel Fortier, Irrigation Engineer in charge of Pacific District Irrigation and Drainage Investigations, of Berkeley, Cal. The author reviews at some length, by means of text and diagrams, supplemented by half-tone views, studies recently made to determine the losses from evaporation in actual irrigation practice, under various climatic conditions, in the State of California. Although the most important evaporation losses to be considered are those from the irrigated soil rather than from water surfaces, yet for purposes of comparison the studies have included water as well as soil evaporation. Earlier studies of evaporation from water surfaces are of course available, but we do not now remember that many if any extensive observations on water surfaces in hot, dry parts of the world have been published. Mr. Fortier's diagrams and figures for water evaporation in California will therefore be of particular interest, especially as they take into account the effect of the temperature of the water itself, the humidity of the atmosphere, the wind velocity, and the effect of shade.

The portions of the studies of most significance, as has already been intimated, are those relating to evaporation from the soil. The loss of moisture from irrigated lands, Mr. Fortier shows, may be controlled in large measure by the mode and frequency of applying the water to the land, and particularly by maintaining a mulch over the irrigated area. Ordinarily, the cheapest available mulch that can be provided is the top layer of the soil, pulverized by cultivation.

Although Mr. Fortier's article relates wholly to evaporation losses in irrigation, it is obvious that soil mulches would be equally effective and just as easily applied for preventing evaporation losses from cultivated fields in the Eastern United States, and that in some years (witness the present season in portions of New York and New England) the prevention of these losses would be of great value. This is a fact scarcely recognized by Eastern farmers, but one which they might well profit by. To secure the greatest reduction in evaporation losses by soil mulches, it is of course necessary to begin early in the season and to continue the work with regularity as occasion may demand. Such work is by no means lost, even if the season turns out to be one of abundant rainfall, since thorough and frequent cultivation, as every farmer knows, is of great value in keeping down weeds. It is also an advantage in some soils through the soil aeration which it affords.

Mr. Fortier points out that in irrigating land with a view to reducing evaporation the water should be applied in large quantities at long intervals, instead of in small quantities at frequent intervals. By this means the top layer of soil from which the evaporation chiefly takes place is kept wet as small a part of the time as possible. This brings to mind the foolish utterances of an engineer, some years ago, embodied in a report submitted by him on water-works matters in a Texas city. This engineer assumed that a given number of inches would be required to keep lawns and gardens in shape during summer weather, and, with a view of minimizing the draft upon the public water supply, recommended that the water be applied in some very small fraction of an inch (1/64-in., as we remember it) daily. Any one at all familiar with the principles of water utilization by growing vegetation, and with the usual methods of lawn sprinkling employed by householders, knows that the application of water in such small quantities daily is almost worse than useless. A large percentage of the water so applied during hot, dry weather is swallowed up, figuratively speaking, by the atmosphere and the small remaining portion that reaches the growing things merely stimulates a surface root growth and thus renders the plants all the more likely to succumb to dry weather. This, of course, is particularly true as regards grass.

It is high time that the people of the country at large begin to realize the value of our water resources. This journal has for years persisted in urging water-waste prevention in connection with municipal water supplies. In different but perhaps scarcely less important ways it is quite as essential to the welfare of the country that every possible care should be taken to prevent water waste in irrigation. The studies under this head carried on by the Irrigation and Drainage Investigation division of the U. S. Department of Agriculture deserve not only commendation by the people at large, but also ample financial support by Congress; and, we may add, they may well be furthered by all the several States of the West, as has already been done in the way of financial contribution by the State of California. The broad general subject of water conservation might very properly receive consideration, as we presume it will, by the Inland Waterways Commission appointed some months ago by President Roosevelt.

LETTERS TO THE EDITOR.

Error in Diagram for Computing Weir Discharge.

Sir: In an endeavor to verify some calculations of the flow over weirs recently, I used the diagram on p. 157 of your issue for Feb. 8, 1906, and as the diagram did not agree exactly with the calculations, I read the article accompanying it, and noticed that in the bottom line of the diagram the scale of lengths of weir was not quite three times as far from the scale of discharges as the scale of heads on the weir, which, as is stated in the article, should be its position. In order to make the diagram correct, the lower scale should be about 5/8-in. lower on the page than it is.

Yours truly, Frank S. Bailey.

East Braintree, Mass., Aug. 29, 1907.

"Laborers" in New York Department of the State Engineer.

Sir: Referring to the attached news item relative to the classification by the New York State Civil Service Commission of the laborers employed in the Department of the State Engineer, and calling these men axemen if engaged in field work, and office assistants if employed in the various bureaus: I think these appellations inappropriate. It is well known that, besides axemen, survey parties include stake drivers, stake carriers, front and back flagmen, pegmen, tapemen. To call all of these men axemen is certainly a misnomer. And again, to designate laborers as office assistants is another absurdity. If they perform office work they are either typewriters, stenographers, clerks, bookkeepers, computers or what not.

It seems to me that the titles of the Civil Service men employed in the State Engineer's Department should be revised to conform to modern nomenclature of transit, field, level, topography and other surveying parties. For instance, there should be instrumentmen to run the transit or level. At present the assistant engineers and levelers are supposed to be in charge of field parties, and are obliged to furnish instruments for some subordinate to handle. This duty may be assigned a laborer, a chainman, a rodman, or other employee, as the assistant engineer or leveler may elect. In other words, these latter men must furnish instruments, when it is the province or business of the State of New York to do so.

Respectfully,

"Civil Service Reformer."

New York, Aug. 24, 1907.

Cattleguard for Turning Range Cattle.

Sir: I observe in your issue of July 25 a description of a cattleguard planned by me when Chief Engineer of the Oregon Railway & Navigation Co., and for which I obtained a patent in February, 1906. I desire to call attention to the fact that my form of guard was patented, as it has been suggested to me that the publication of a description of it without such notice might in some way affect my rights as patentee.

There is no special difference between the design as patented and the guard adopted as strandard by the O. R. & N. Ry. Your cut is, like all your illustrations, a most excellent one, and shows it about as I first designed it. I have, however, discarded the through bolts on account of the difficulty there would be in taking out defective ties. I have increased the space between ties from 6 ins. to 8 ins., as the latter is about the size of the largest horseshoe, and it would, of course, be dangerous to catch and hold a horse's foot as in a trap. The 8-in. spacing also affords better facilities for tamping the ties. The same is true also of the decrease in their depth from 16 ins. to 12 ins., and I believe the lesser depth will be fully as effective in deterring stock. As to the length of the ties on the cattleguard: 11 ft. has always been the standard with the O. R. & N. Ry., or 1 ft. more than is customary on other roads.

Yours very truly,

W. H. Kennedy, M. Am. Soc. C. E.,
Consulting Engineer.

Western Pacific Ry., Winnemucca, Nev., Sept. 3, 1907.

[We are informed that this cattleguard has been adopted as standard on the Western Pacific Ry., and is in use also on the Northern Pacific Ry. and the Portland & Seattle Ry.—Ed.]

Concrete Floor on Soft Foundation.

Sir: In your issue of Aug. 29, 1907, I note a question by "Construction Company" in reference to laying a concrete floor of a building upon filled ground above 7 ft. of black mud. The condition described is the same as the marsh land at Long Island City, and I know of two factories where the floor was laid as your correspondent proposes that have proved to be failures from settlement of the ground.

In another case, in ground of this character, the wall footings of the building spread apart, owing to the fact that the ground furnished very slight lateral support and although the bearing piles under the walls were well driven, this spreading outward became so serious as to endanger the structure and necessitated putting in a great number of ties from wall to wall.

A satisfactory solution of the problem of supporting the floor and at the same time tying in the wall footings was made in the erection of a large factory last year, and I would take pleasure in showing the details that were worked out to your correspondent if he would care to call at my office. In general terms, the method is to provide reinforced concrete beams tying the wall footings to the center piers, and extending continuously across the building from side to side, and supporting a reinforced slab on these beams. The form work for these beams and for the slabs is made by digging trenches and forming the earth between the trenches either flat or arched as desired. If care is exercised, the concrete may be deposited in these earth forms without the use of wooden centering.

In the case of many buildings, it is thought desirable, instead of filling in earth up to the first floor level, to excavate and to provide a low basement, the floor being laid in the manner described, a basement being always serviceable for storage and the first floor being very much drier and more healthful if it has an air space underneath instead of resting directly upon the ground.

Yours very truly,

A. B. Miller, M. E.,
Building Construction.

140 Cedar St., New York, Aug. 31, 1907.

Sir: Referring to the inquiry in your issue of Aug. 29, relative to laying concrete floors on the mud of the tidal marshes, I should like to say that the question of the upheaval of same through freezing is not as important as they think. If the foundations of the building are deep enough, the frost has no more effect than it would have in a building placed on solid ground. The important feature of such work lies in the necessity for entirely enclosing the area within the foundation walls. The material in question has about the consistency of grout, and unless perfectly confined will

force its way out under the foundations, and as such foundations are usually built on piling it is often very doubtful whether the space is entirely enclosed. During an experience of over five years in a variety of work with this material, I have found that tamping sand, gravel, ashes or the like will increase the bearing power very considerably. I have found it especially true in setting trolley poles that when sand was used to fill the holes (the sod was undisturbed), they would stand about as well as in a sandy soil. Your correspondent should be sure that he has bottom at the required depth, as I have found streaks of sand in varying thicknesses at different depths before arriving to the real bottom, in which case a timber platform was laid on the piling before starting the masonry. If the character of the building contemplated will warrant it, I would suggest putting in piers and building a regular reinforced floor system.

Yours truly, F. D. Hain.

Joliet, Ill., Sept. 2, 1907.

Sir: We notice, in your issue of the 29th ult., an inquiry from a construction company on concrete floors on soft foundations, and take great pleasure in advising that we have had long experience in this class of construction, especially on the Pacific coast, and in San Francisco, where this line of work is very much used, owing to efforts to counteract earthquake stresses.

We can assure your correspondent that there is no danger whatever from freezing, and we are confident if he would reinforce his concrete slab sufficient, it would counteract any tendency to an upheaval of any sort. We have one large job in San Francisco in the plant of the Western Meat Co., where a very serious problem of mushy foundation caused by seepage water was encountered, and this was successfully overcome by laying a mat of 8 ins. of concrete reinforcement with our wire fabric to take care of the upward pressure. It is now doing this work in splendid shape.

Yours very truly,
American System of Reinforcing for Concrete Construction, W. A. Collins.

189 La Salle St., Chicago, Ill., Sept. 6, 1907.

Another Pivotal Pile-Driver.

Sir: Referring to the article entitled "A Pile Trestle Erected with a Pivotal Pile-Driver," in Engineering News of Aug. 15, 1907, and the claims instituted by Mr. Balfour: During the year 1900, while engaged in constructing trestle work at the Manzanillo Harbor Works, Manzanillo, Mexico, the writer used a batter pile-driver almost identical in construction with the one described by Mr. Balfour. This pile-driver was designed by Mr. Bert Lindemann, C. E., then General Manager for Mr.

Another Pivotal Pile Driver.

E. K. Smoot, M. Am. Soc. C. E., who was contractor for the harbor works.

Later, in 1905, while the writer was engaged as Engineer and Superintendent of the Cebu Harbor Improvement, Cebu, P. I., for J. G. White & Co., he made sketches for a pile-driver, details of which were worked out by Mr. A. S. Williams, M. E., for driving foundation piling (submerged work) at different angles. The heads of the piles, which varied from 25 to 60 ft. in length, were driven to a depth of 23 ft. below mean low water. The accompanying view gives a good idea of the construction of this driver. A brief note on the various parts will suffice for a description. A traveling carriage mounted on double-flange wheels; a tower frame built upon the carriage; a pivot beam supported by and securely tied to the tower frame; a grooved piece fitting over the pivot; leads 85 ft. long, sliding in the pivoted groove; leads held to gage by U-shaped steel yokes; leads swung to desired angle by means of a tackle and held in position by a sliding yoke and drop pins connecting with a steel plate segment at the base of the tower. The view shows the leads dropped to the bottom of the trench excavation, 25 ft. below M. L. W. and 57 ft. below top of trestle. The sheaves for hammer and pile lines were attached to the pivot by a swinging toggle, so that the hammer line always centered with the leads at any angle. The hammer weight was 3,200 lbs. Piles were driven to the water surface in the usual manner, thence to desired depth with a follower pile. Piles were kept in alinement below water surface by means of a guide at the bottom of the leads, and guides attached to the follower pile. The gage of the track for the carriage was 17 ft. 4 ins.

The distinctive principle claimed by Mr. Balfour, in your issue of Aug. 29, 1907 [under Notes and Queries, p. 231], i. e., "the regulation of the height of the pivoting point, etc.," was one of the principal features of each of the pile-drivers described in this letter, and especially so in the one used at Cebu, P. I., by which the piling under the inner or land side of the sea wall was driven vertical, and the other piles driven on increasing angles corresponding to the resultants of forces at the points where driven. In a pile-driver of this description it is an exceedingly simple matter to arrange the tower so that the height of the pivot can be changed in a few minutes. With both of the pile-drivers mentioned the proper angle or batter was given the driven pile by the angle to which the leads were swung, and "without side motion of the supporting frame."

Yours very truly,
William J. Mozart,
Assoc. M. Am. Soc. C. E.

93 Hancock St., Malden, Mass., Aug. 29, 1907.

[Attention is called to an extract from a letter by Mr. Balfour in the Notes and Queries column of p. 231 of our issue of Aug. 29, 1907, in which he recognizes the numerous other instances of the use of pivotal pile-drivers.—Ed.]

A Remarkable Blunder in Bridge Construction.

Sir: I agree with you in keen regret over the disastrous failure of the Quebec bridge and the effect it will have upon public confidence in engineers and engineering construction.

In the material used, a variation in the physical properties of 10% would be cause for rejection, and prudent engineering would require such inspection of material and workmanship as would bring results materially within that variation. In the design of a structure, however, there is an almost unlimited variation of engineering talent and product.

When the material used is rotten, it is practically sure of detection. When the design is defective, a factor of safety covers a multitude of sins and the defects of the design generally escape detection.

In looking for the cause of the Quebec disaster there appears to be one hundred chances of finding it in the general design to one chance of locating it in the material.

As an illustration of the blunders in designing and erection which actually creep in sometimes, even on important works, I venture to offer for publication the following interesting correspondence. While it all happened a score of years ago, it conveys a lesson that may be useful to-day.

About twenty years ago a bridge was erected over the Big Warrior River near Cordova, Alabama, for the Kansas City, Memphis & Birmingham R. R. Co., which was considered a model design and was illustrated with complimentary comment in the "Railroad Gazette" of June 29, 1888.

About the same time a bridge of similar design was erected by the same bridge company over the Ohio River at Cincinnati, Ohio, for the Chesapeake & Ohio Ry., having a channel span of 550 ft. and two approach spans of 490 ft. each.

When this last construction came to my notice I communicated with the bridge company; and to the railroad company I wrote as follows:

Canton, Ohio, Feb. 14, 1889.

Mr. ————,
Birmingham, Ala.

Dear Sir: * * * * I am strongly impressed with an idea that some members that should be in the trusses have been omitted and leaves the bridge dangerous, under the loads stated in that article. * * * *

I will also be obliged if you will give me any other information in relation to it that is not given in the article stated above, and state whether the bridge was tested with the loads mentioned in the "Railroad Gazette."

I will advise you of the result of my examination at an early date after receipt of information. Don't test it before you hear from me. Yours truly,

J. W. Pearl.

The reply which I received from the bridge company, dated Feb. 21, 1889, with lithographs of the Cincinnati bridge contained the following:

I cannot understand what you should find in error in construction of the Big Warrior bridge as the computations were very carefully made in our computing office.

If, however, you will kindly send on your strain diagram, as you compute it, I will have it compared with our computations and endeavor to account for the discrepancy.

Hoping to hear from you, I am,
Yours very truly,
————.

Reply from the railroad company dated Feb. 28, 1889:

Dear Sir: I am sorry that I have not the time to give this information, as it is not in such form as to be readily copied.

The bridge was designed, built and tested by bridge experts, and was found to be satisfactory in all its details.

The paper must have been in error if it has omitted any necessary member of the bridge.

Yours truly,
————.
Chief Engineer.

My reply to the railroad company, March 4, 1889:

* * * * Although I am not a "bridge expert," I come in contact with many who advertise themselves as such, and I have excellent reasons for the belief that although your bridge was designed, built and tested by that class, it does not necessarily follow that your bridge is all that it should be. * * * *

I cannot believe the "Railroad Gazette" in error at present, because their perspective view, which was made from a photograph, corresponds with the detail drawings furnished by the ——— Bridge Co.

It was with the idea of doing you and possibly the public a favor that I asked for the information. * * * *

No harm can come from giving me the data asked.

* * * * * * *

I would also be pleased to learn who the bridge experts were who designed and tested the structure and how it was tested.

The information I get from the "Railroad Gazette" is just sufficient to warrant me in following the matter up, and I am determined to do it.

If I cannot get the data desired in any other way, I shall bring the matter before the readers of some of our best engineering papers, or the American Society of Civil Engineers, and see what I can learn in that way. * * * *

Yours truly,
J. W. Pearl.

Reply from the bridge company, March 26, 1889:

* * * * I cannot tell you precisely who made the computations for the Big Warrior bridge. It was either our Chief Computer, or an assistant in the computing department under the supervision of the former. * * * *

I should be obliged to you if you will point out to me as soon as you make the computations, just what you find wrong; as we may thus be able to clear away the apparent difficulty. * * * *.

From bridge company, April 19, 1889:

You are correct in supposing that a counter-rod A in the Big Warrior bridge was omitted.

It is one of those unaccountable things that sometimes occur, but as a matter of fact it did escape the attention of both our computing office and our drafting office.

* * * * * * * * *

Enclosed please find copy of a letter which I have just written to Mr. G————, relating to the matter and which gives all information relating thereto.

Very sincerely yours,
————.

From bridge company, April 19, 1889:

Mr. G————
Engineer of Bridges, Kansas City, Fort Scott & Memphis R. R. Co., Kansas City, Mo.

Dear Sir:

* * * * * * * * *

We regret very much to say that through some unaccountable oversight the counter-rod A in adjoining sketch was overlooked and omitted when the bridge work was made and shipped, and subsequently erected. * * * * The maximum compression in the member B is 25,800 lbs., for which,. as we state above, through some oversight in our computing department, no provision is made. A 2-in. round rod should be put in at A. * * * *

Yours very respectfully,
The P—— Bridge Co.,
By ————
Engr. of Construction.

From the railroad company, April 30, 1889:

It is due to you that I should give the information asked for in your letter of March 4, as the designers of the Big Warrior bridge at Cordova, Ala., have stated that there was an omission in the bridge and that they would make the omission good.

They claim, however, that the bridge was safe as designed and erected.

The calculations on the strength of the bridge have, at different times been made by several persons. It was also inspected by a bridge man, especially employed for the purpose. * * * *

The reinvestigation is due to your letter, and for that I thank you. Yours truly,

————,
Chief Engineer.

I was also informed that additional members were found to be necessary and were later placed in the spans of the Chesapeake & Ohio Ry. bridge over the Ohio River at Cincinnati, Ohio.

The repetition of the error in other designs does not indicate a mere omission or oversight, and all efforts on my part to determine the identity of the person responsible for the errors were evaded by both the railroad company and the bridge company.

The claim that the bridge was safe as designed and erected, with a stress of 25,800 lbs. not provided for, may sound plausible to the purchaser!

That the bridge did not fall is due to four indeterminate possibilities.

(1) It did not get the live load it was calculated to carry.

(2) Some unbraced eye-bars carried an unknown amount of compression.

(3) A section of top chord, proportioned for compressive stresses only, withstood an unknown bending stress.

(4) Unknown inertia of the material and friction of pin-connected members resisted the momentary stresses, as the load passed the critical point, as is the case with the brave bad boy skating on thin ice.

The fact that four bars, having a sectional area of 3.14 sq. ins. each, were placed in the trusses at the danger points, is sufficient evidence that the bridge was not safe without them.

Too many engineers work by rule instead of reason; on routine plans they "turn out the work," make money for the stockholders and lead in the race for promotion to the desk of Chief Engineer, while the plodder, who takes time to reason and prefers to be right and safe at all costs to being president of the company, remains at the board in the room upstairs.

With the "rusher" in the chief's chair to dictate the designs and the "ruler" in the computation room, the special designs get scant consideration, and such results as the Big Warrior, Cincinnati and Quebec bridges may be expected.

The common rule for counter-bracing is to use it or omit it as the stresses indicate, in nearly all cases, and this part of the structure is designed with or without a margin for safety, while all other parts have the usual allowance of 3 to 5.

A slight variation from the partial loadings assumed may demand the counter-brace and the structure fail in consequence, or place an abnormal and destructive strain in some other member.

I now regret that for nearly twenty years I have refrained from publicly mentioning these cases, and several others that have attracted my attention.

With the states prescribing no license or qualifications as to who may practice or assume the title of Engineer or Consulting Engineer, and no penalties for malpractice; and a press that too often omits the names of persons responsible for faulty structures, if the designer happens to be a good advertiser, it is not surprising that disasters are of so common occurrence and the practical public pays little respect to the title of Civil Engineer.

When the coroner's investigation is over, it too often appears to be a rotten timber, a rusted bolt, or a crystallized bar that bears the censure.

James W. Pearl.

Benton Harbor, Mich., Sept. 10, 1907.

The Quebec Bridge Disaster.

Sir: The study of your very excellent discussion of the failure of the Quebec bridge, and especially your reference to our lack of knowledge in proportioning lattice for columns, brings forcibly to mind the crudeness of our rules covering this detail. The proper unit strain for a column is based on the moment of inertia of its section. For the ordinary chord or post section we carefully compute this moment about an axis perpendicular to its webs; and, in cases of doubt, about an axis parallel to its webs. But in the latter case do we investigate the sufficiency of the lever arm to carry this moment? If we depend on the full moment of inertia, there must be provided a material connection between the extreme fibers and the neutral axis sufficient to carry the horizontal shear induced by the moment. Empty air will not do it. The lattice called for by our ordinary thumb rules has proved adequate in the moderate sized columns so far tested; but your position, that the latticing of the main compression members at Quebec was inadequate, seems to be well taken.

J. P. Snow,
Bridge Engineer, B. & M. R. R.

Boston, Mass., Sept. 14, 1907.

Sir: In connection with the Quebec bridge, I should like to ask a question about riveting. I examined several pieces of the fallen bottom chords and noted what appeared to be evidences of the shop-rivets not having filled the holes. The various plates of which the members were built up had been given a coat of shop paint, some of which had run into the rivet holes. When the hot rivets had been put in and headed-up, many of them appeared to have bent over to one side, fusing the paint at the same time. The latter when cooling had contracted into ridges or corrugations, which partly filled the vacant spaces, and remained in many cases unaffected by the collapse. In other cases the rivets had been wrenched loose, but in several of these also the ridges of paint were visible on the shank and stood out 1-32-in. or less. Had the rivets filled the holes there would, of course, have been no such corrugations visible. If several 1 × 12-in. plank were stood on end and loaded, they would deflect a good deal more than if nailed tightly together. Would this hold good with a box-shaped member whose rivets did not fit closely?

Yours very truly,

Sept. 11, 1907. A. R.

[Many tests of riveted joints have shown that a well-driven rivet in shrinking draws the plates so tightly together that the friction of the plates on each other gives the full calculated strength, apart from the shearing resistance of the rivets. Of course if the head is badly offset and the shank is deficient, the rivet may bend and the full friction hold will not be obtained. In answer to the question at the end of our correspondent's letter: the compression members depended entirely for their stiffness, as we showed last week, upon the latticing that bound them together, and the latticing angles were effective only so far as the rivets held them in place. Any motion in these riveted joints would permit a member to deflect and the initial bend in A9L must have been accompanied by such motion in the lattice riveting. —Ed.]

Sir: You have already received many words of commendation from appreciative readers of your articles on the Quebec bridge disaster. I would like to express my appreciation for the clear way in which you have presented to the engineer's mind all the information yet available, and for the temper and tone of the way in which it has been done. Both are admirable.

If investigation should fail to disclose further information in regard to the cause or causes which brought about the collapse of this huge structure, I believe the majority of bridge engineers would finally concur in the opinion that three things are chiefly to blame: First, and principally, the failure to design these enormous struts so that their four component webs would act integrally. This has been pointed out by Engineering News and by Mr. H. S. Wood, M. Am. Soc. C. E., in his letter of Sept. 5.

Second, the inspection or engineering supervision that would allow an injured member to be repaired and put into such an important position.

Third, secondary or rather eccentric stresses. We may well suppose that there has never been a strut built up of plates and shapes, riveted together, which was exactly straight (that is, the line through the centers of gravity of all cross-sections—an infinite number of points—is never a straight line, also that square ends frequently are not finished exactly square, and that pin-holes frequently are not bored exactly at right angles. If, after A 9 L had fallen in handling and broken, it was patched up in the field, so that it appeared to be straight and satisfactory, what was its real condition? Is it not very likely that it was much more out of true in the above respects than it was when it left the shop? Its true condition would be very hard to find out, probably impossible. The formulas for long columns give a measure for column eccentricity, as you pointed out some months ago, but with latticing too weak, column formulas are only deceptive. It is of no use to make the radius of gyration about the vertical axis greater than that about the horizontal axis if the channel sides of a compression member are not tied to each other so as to produce the integral resistance assumed. The member A 9 R seems to have been only a little stronger than A 9 L, as you have remarked, and all the compression members of this structure are under suspicion in the minds of engineers until further developments.

The disaster is appalling. Every engineer must regret it most keenly, and feel the greatest sympathy for those who suffer most from it.

What is the lesson? I think the profession will say, along with you, that this question can only be answered by tests—very extensive tests—covering not only the design of latticing for such large struts, but that of smaller ones as well, and also a good many other points about which we are still groping in the dark. In this day of great achievements the building of such large bridges should not stop, but it must go on with the restored confidence of the public, and with absolute safety.

Engineering in general is not an exact science—no applied science ever can be—but we are fond of thinking ours is one of the most exact of the sciences, and that bridge engineering is one of the most satisfactorily exact of any branch of engineering. But the tests are needed; we all know that; needed whether the Quebec bridge fell or not; not a few tests, but a great many. A few tests worked up by a mathematical gymnast may be deceptive. The expense involved in making tests of sufficient number and of extensive enough scope for safe deductions would be so great that only the national Government or a man with millions to give away could cope with the financial end of such a proposition. What would be more fitting and appropriate than that a man who made millions in steel should furnish the funds for such an undertaking? I vote in favor of acceptance.

E. D. Cummings.

3110 West North Ave., Baltimore, Md., Sept. 14, 1907.

Sir: I have read with great interest the account which you publish in the Sept. 5 issue of Engineering News concerning the Quebec disaster. The discussion which you there present is of the greatest importance not only to those whose work is in part or in whole the design or erection of steel bridges, but to the whole engineering profession, civil or mechanical.

The point of greatest interest to me in your discussion was the very high value of the stresses allowed, and the very small factor of safety resulting, in the design of the compression members of that great structure. From the viewpoint of the mechanical engineer, the stresses allowed are exceedingly dangerous, and the true factor of safety reached the alarmingly low value of LESS THAN ONE AND FOUR-TENTHS. You may be inclined to question this statement, but my reasons for making it are entirely sound, and are as follows:

The true factor of safety of any structure is found by dividing the load which it is to be called upon to sustain into that load, of the same character as the actual load, which will destroy the structure. Perhaps a better way to state the same fact would be to define the true factor of safety as the quotient obtained by dividing the static load which will just destroy the structure, by the static load which will produce the same stresses as are produced by the load for which the structure is designed. In the case of the Quebec bridge, I infer that the stresses produced, theoretically, in the compression members, by the dead load, were 16,000 lbs. per sq. in. The stresses nominally produced by the live load were 4,000 lbs. per sq. in. more. As a matter of fact, we know from the principles of elementary mechanics that the stresses actually produced by such a live load would be more than this nominal value, on account of its sudden application, and might often reach double that value, or 8,000 lbs. per sq. in.

This gives us, for the minimum possible value of the compressive stresses, with the bridge fully loaded with two running trains, 24,000 lbs. per sq. in. The unit load which would destroy the compression members, is probably not so great as 35,000 lbs. per sq. in., so we get for the maximum possible value of the true factor of safety, assuming that the workmanship is perfect, the materials perfectly homogenous, and the design faultless, a trifle more than one and four-tenths.

As a matter of fact, none of these conditions were true. The design was not flawless, for it is beyond the power of the ablest designer to proportion a great strut of the type used in this bridge in such a way that the line of force shall intersect every section in its center of gravity. The line of action of the forces will intersect some of the sections at least, at some point other than the center of gravity, producing a stress greater than the one computed. The workmanship is not perfect. Not all of the rivets will perfectly fill their holes, nor will all of the butting plates be cut perfectly square so as to bear equally for the entire length of the joint. As a result, the stresses will be unequally distributed across the sections, making them at some places appreciably greater than their computed value. Nor is the material entirely homogenous. No two plates were finished at exactly the same temperature, nor have any two exactly the same chemical composition. There will be variations in the thickness of the plates, even with the most careful rolling, which will reduce the computed section at some points, and change the position of the center of gravity of the sections in many places.

Granted that the individual struts were perfect in design, material, and workmanship, we are still unable to compute exactly the forces which will act on each one. We cannot tell what are the effects of changing temperature or of winds, not only directly, but indirectly by swinging the structure from true verticality. We might go on at great length considering such causes, each one infinitesimal in itself, but which, when added to a sufficient number of other causes, equally infinitesimal, will help to swell a total which may be no inconsiderable proportion of the force acting.

There is an old adage that a chain is no stronger than its weakest link. The strength of a bridge, like that of a chain, is not the average strength of its members, but the strength of the weakest one. The longer the chain, or the bigger the bridge, the lower the probable value of that strength. In the Quebec bridge there were 80 chords, the failure of any one of which would result in the destruction of the bridge. Is it any wonder that in a chain of so many links, that one should be only 70% as strong as it might be?

The writer has for the past year been engaged in the test of some cast-iron columns. Every precaution was observed that experience or ingenuity could suggest to make these columns exact duplicates one of another, and to test them under exactly similar conditions. Every one tested was perfectly sound. Tension tests indicated practical uniformity of strength in all bars of the same size. And yet these columns varied more than 30% in strength. Of course steel is a more reliable material than cast iron, but then the struts composing the lower chord of the Quebec bridge were not turned solid cylinders, with carefully milled knife-edge bearings. I am compelled to believe that many of those struts varied more than 15 or 20% from the mean strength.

Are we not playing the fool, we engineers, when we assure ourselves that the factor of safety of the Quebec bridge is 3½, if a load 40% greater than the actual load will theoretically destroy it? Are we not guilty of criminal folly if we load such a structure to within 70% of its theoretical strength, when we know by our tests that out of 80 vital members, 5 will probably have less than 85% of their theoretical strength, and some of these will be called on for more than their share of the load?

The statement is made in Engineering News, or, rather, the question is asked, "Did one of them fail under a load only one-half the elastic limit of the material in it?" The question implies that the elastic limit of the material *in compression* was 36,000 lbs. per sq. in. What is there to warrant such a belief? Were any tests made to determine the elastic limit of this material in compression? Is the figure given the elastic limit of the material in tension, or is it the yield point? Now we all know, or at least ought to know, that the elastic limit of structural steel is anywhere from 3,000 to 10,000 lbs. per sq. in. less than the yield point. We know that the process of rolling such steel raises the elastic limit in tension at the expense of the elastic limit in compression. A knowledge of the exact value of the elastic limit of structural steel, in compression, is a vital point in the design of these great struts. It can only be determined by delicate apparatus never seen in a commercial laboratory. Therefore we substitute for this unknown but vital constant, another one, having no value for the purpose. It is easy to obtain, therefore we use it. It is as wrong to use the tension yield point for the compression elastic limit, in computing the strength of such a structure as this bridge as it would be to deliberately incorporate in it a lot of burned steel.

Very truly yours,

Forrest E. Cardullo.

Syracuse University, Syracuse, N. Y., Sept. 7, 1907.

Sir: The writer has studied with keen interest your report on the collapse of the Quebec cantilever, in your issue of Sept. 5. Insomuch as this failure casts doubt on the safety of great engineering structures and the work of the profession in general, since connected with this work were engineers who rank among the first in the profession, and who have done perhaps as much as any to further high-grade construction, it would seem in order to bring out for discussion those features of the construction of the enormous compression members which undoubtedly failed, to determine (if possible) wherein they differ in general from those of other structures of magnitude, and to question the data upon which the design was based.

It should be noticed, first, that the compression member which is supposed to have collapsed, consisted of built webs in the vertical plane with the usual flanges, and latticing in the lateral plane. Nearly unbroken success in the line of steel construction has, perhaps, caused engineers to lose sight of those elements of design which have not been determined, either theoretically or by practical measurement. For example, what engineer is able to compute, with certainty, the stresses in the lattice bars of the ordinary column in a bridge structure? What attempt has been made to measure these stresses? What rule or method of comparison has been adopted generally by engineers, in proportioning such lacing where members are increased above the size of those which have been tested? If, for example, with a 15-in. channel, 2½ × 7-16-in. lattice bars, one ⅞-in. rivet is sufficient for connection, how many should be used where the section is increased ten times or thirty times the area of this channel?

The following is a general specification due to Mr. Cooper: "The size and spacing of the lattice bars should be duly proportioned to the size of the members." This specification appears rational; but not particularly explicit. In much of Mr. Cooper's work which the writer has seen, large columns have been designed with a heavy cover-plate thoroughly riveted to the various webs, latticing being used on but one side of the member. Can the doubt raised by the failure of a compression member latticed on both sides be considered to apply to the column made up with a heavy plate thoroughly riveted in place of the latticing?

In view of the enormous increase in the lateral stiffness and the number of connecting rivets which would unquestionably be used with the cover-plate, the writer is of the opinion that it is rather a long jump to cast doubt upon one type of column from the behavior of an entirely different species.

While the science of computation of the stresses in a frame structure has unquestionably reached a basis of scientific perfection, what can we say as to our knowledge as engineers of the properties of the material which we rely upon to resist these forces? We pick up, for example, Fidler's "Practical Treatise on Bridge Construction." We find outlined there the dynamic theory of the effect of range of stresses. We pick up another treatise, say, for instance, "Theory and Practice of Modern Framed Structures." We find there the maximum and minimum formulas of Launhardt and Weyrauch. We pick up Mr. C. C. Schneider's specification for bridge construction, and find he recognizes neither. Question: Are engineers at all agreed upon any specific basis of working stresses? Are not the conceptions of the elastic properties of the material we are working with, held by those most prominent in the profession, radically different? What advance has been made in the methods of testing in the past fifty years by engineers? Have they kept in any wise abreast of the times? Is it possible to determine by actual measurement what the fiber stresses are, in each and every portion of a compression member under test, at each and every period of the test?

The writer claims it is entirely practical to do so, and that it only requires a little experimental investigation to determine these minor points in bridge construction. The importance of these will probably not be underrated in the future to the extent it has in the past, if the lesson of this unfortunate failure is not lost to the profession.

The writer spent some five years of his spare time, some years ago, in an endeavor to work out a practical method of settling some of these hitherto indeterminate features and questions of design, and presented the result of his work in a paper to the American Society of Civil Engineers (see Transactions, Vol. XLVIII., Aug., 1902). In the course of this investigation the information secured seemed to bear upon the question of a rational basis for the determination of working stresses, and to indicate that the limit to which medium steel may be strained without injury is not far from five-eighths of the commercial "elastic limit" or yield point. If these results have value the necessary provision that should be made, where built up sections are used, to keep within this limit, should, apparently, be readily determined by the same means.

In the line of concrete work the various associations have succeeded in getting a liberal government appropriation for the purpose of carrying on an investigation, to increase their knowledge of the properties of this material. Are structural engineers so confident of the perfection of their knowledge of the properties of the material they are using that they do not need to profit by the example of the concrete men? As few, if any, of the engineers engaged in construction can afford the time and necessary money to devote to purely scientific investigation while engaged in earning a comfortable remuneration for practical work, it would seem as though some such means of securing results should be adopted.

As a matter of fact the writer believes that less doubt is connected with the design of concrete compression members for enormous loads than is the case with steel, except when some such conservative design is used in steel construction as was adopted by Sir Benjamin Baker in the construction of the Forth Bridge, although there can be little question that the tension members in this structure were inferior to those of the Quebec design.

If the writer's judgment is not at fault we will probably see some of the uncertainties of steel columns eliminated in the near future by the adoption of the combination of concrete and steel, thereby reducing the cost while giving a solid section in which the doubt as to how component parts of the section act together will be reduced to a minimum and the question of deterioration of the metal will be to a large extent eliminated.

Respectfully yours,

C. A. P. Turner.

Phoenix Bldg., Minneapolis, Minn., Sept. 9, 1907.

[The reader will note that Mr. Turner's suggestions with respect to the latticing of compression members are directly in line with those made in the editorial published in our last week's issue. His letter was written prior to the publication of that issue, but was not received till after publication.—Ed.]

Our attention is called to the fact that Mr. J. W. Schaub, in his letter published last week, referred to possible reversal of stress in the second diagonal member of the *cantilever* arm, while in discussing his letter we referred to the stresses in the *anchor* arm. Our readers who are interested can refer to the illustrations in our last issue and form their own opinions as to the probability of such stress reversal taking place under the conditions existing at the time of collapse. While it is entirely natural to fix on the erection stresses peculiar to cantilever construction as a likely direction in which to look for the cause of failure, we are informed that the computed erection stresses were nowhere as great as the full live load. Further the bridge was figured for erection stresses with the big 1,000-ton traveler in use clear to the center of the suspended span. Actually, in order to hasten the work of erecting the north half of the bridge, the big traveler was moved back, as shown in the photograph on p. 288 of our last issue, and was already partially dismantled and moved over to the other side of the river when the bridge fell. The small traveler at work erecting the suspended span weighed only about 250 tons.

Besides this, the signs of distress in the lower chord members already recorded, make unnecessary any stress-reversal in tension members to account for the collapse.—Ed. Eng. News.

Notes and Queries.

The left-hand running of trains, noted in our issue of Aug. 29 (p. 237) as being used only on the New York Central Ry. and the New York, New Haven & Hartford Ry., is in fact the standard practice also on the Chicago & Northwestern Ry. Some of the Chicago elevated railways are also run in this way, to facilitate connections with the terminal loop.

The dump-car unloader described and illustrated in our issue of Aug. 22 has been used before, in a somewhat different form. Mr. W. F. Patterson, of Wittenberg, Pa., states that he used the same style of track and jacks, but without the mast and guy lines, on the South Penn Ry., in Somerset Co., Pa. He also states that this earlier form was designed by the late Robert H. Sayre.

C. E. W. asks what states are appraising or contemplate the appraisal of their railways for the purpose of basing taxation or rates.

The states of Michigan, Washington and Wisconsin have had valuations made, and the details of the system employed by the first were described in our issue of Dec. 20, 1900. The work in the other states was not done until 1906 or 1907. In Minnesota, Oregon, Oklahoma and South Dakota (and perhaps in other states) new laws have been passed for valuation of railways by the railway commissions.

THE FALL OF THE QUEBEC BRIDGE.

Two interesting developments of the past week in the matter of the Quebec bridge collapse add considerably to the information given in our last two issues.

We have already reported in detail that the ninth bottom-chord member of the west anchor-arm truss was completely buckled during the collapse, so that it has the shape of the letter S. It now appears that the chord section immediately opposite, in the east truss, chord A 9 R, is buckled in almost exactly the same way as A 9 L. It is buried deeper under the wreckage than the west chord, and its exposed end does not suggest the true condition of the member. When fully examined, however, it is found to have the same complete S-shape as its mate, though perhaps somewhat more closely folded. Not only in shape but also in position are the two chords similar. Both lie in a short distance inward of the original line of the respective truss, and both have their northerly ends inward of the southerly or landward end. The two chords are substantially symmetrical about the center line of the bridge, in shape and position.

This observation, coupled with the fact that no other case of distinct buckling has been so far found in the anchor-arm chords, tends strongly to confirm what we said in our editorial last week:

> If chord member 9 A on the left failed first, then almost simultaneously a member in the opposite truss, *perhaps the chord member directly opposite*, went too.

The observed inward bending of chord A 9 L three days before the collapse has already been reported. Let it be supposed that this bending indicated a state of weakness, of threatening failure, of this chord. While thus bending and shortening, the chord would slightly decrease its stress. The stress decrement could not well be transmitted to the other truss through the bottom lateral system of the anchor arm, and more probably it was transferred through the bottom laterals of the cantilever. Reflection will show that the right-hand truss of the anchor arm, if strong enough, would be fully sufficient to hold up the entire cantilever arm without giving rise to lateral thrust at the shoe plates of the main post (except some amount of frictional thrust due to the elastic retreat of the left cantilever truss). It would therefore be possible for the left truss of the anchor-arm to fail entirely,

without causing the structure to slew or tip; its stresses would simply be transferred to the right-hand truss via the lateral system of the cantilever arm. But such an action would throw double duty on all members of the right-hand anchor arm. If any one of these members were too weak for this service, it would fail before the left truss had completely given up its load.

As we have suggested in the two previous issues, it seems likely that all the compression chord members of this bridge were stressed to near their failure point. We based this conclusion on the fact that nothing had appeared which would indicate that chord A 9 L was a "weak sister," since it was designed, built and inspected with the same care as the other chord members, and presumably was not far different from them in ability to withstand properly its stresses. Now that a second buckled chord is found, this conclusion is strengthened.

Still more light is thrown on this matter, however, by testimony given before the Canadian Government Commission during the last few days. Workmen who had been employed on the bridge testified to having seen bent chords in the bridge some time before the collapse, and it seems that they referred mainly to chords in the cantilever arm, both the right and the left trusses. For example, D. C. Haley, a workman who fell with the bridge but was saved, testified that he had been over the bridge examining the bottom chords on Aug. 8 and again on Aug. 28, in company with several others now dead. They found several places where bending or other distress showed. One of these was in the cantilever arm, on the Quebec side (east or right-hand side); the chord near the splice and the splice itself were bulging or deflecting, "the two outside ribs toward Quebec (east) and the center ones toward Montreal (west)," the center ones having a long S-shape, and several lattice angles were bent. On Aug. 28 they examined particularly the chord A 9 L which was observed to have bent out about two inches. They made a mark on it near the middle as a guide by which they could tell the next day whether the deflection had increased, and they intended to look at it on Thursday evening, Aug. 29; but on this afternoon the bridge fell. Asked concerning the effect of the bending or bulging on the latticing, he said that in some places the lattice angles were bent down and in other places bent up; the damage to the latticing was not at the place of greatest bulging but near it. On Aug. 8 he had seen a number of men at work on this chord with four jacks, trying to get the webs to meet flush. Another witness testified that one of the Indian riveters, now dead, told him several weeks before the collapse that one of the chords on the Quebec side (right-hand truss) had been "forced."

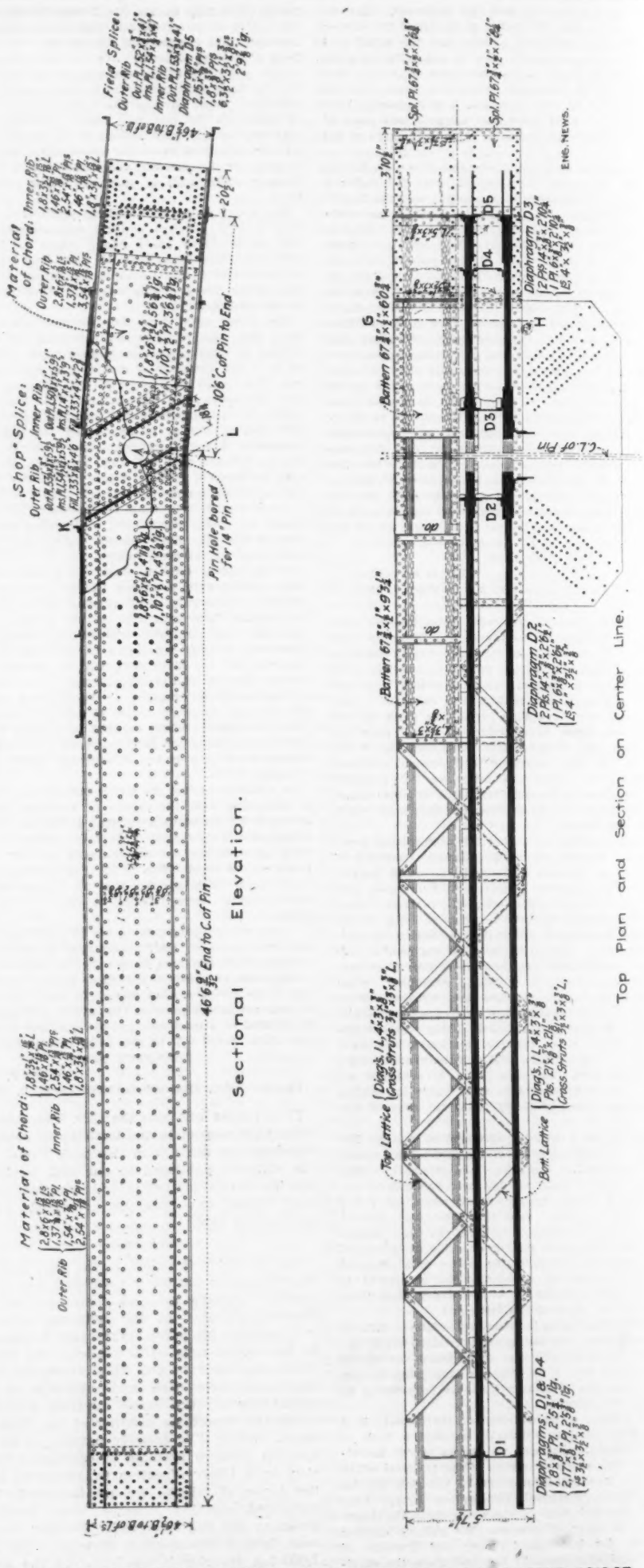
Concerning the knowledge of the foremen and others in charge, of these conditions, Haley testified that the general foreman, Yenser, knew all about it and was scared to death. On the day of the collapse Haley noticed that Yenser sent a carload of stringers back to the yard and heard him say that his life was in danger as much as anyone else's. Asked if he remembered any instance where Yenser followed the advice of Birks or others in charge instead of his own judgment, Haley said that Yenser moved out the traveler the last time against his own judgment. Haley overhead a conversation between Yenser and Birks, when Yenser said, "Why don't they let me take down that traveler and get that load off before we get more steel on?"

Clark, the foreman of the storage yard, testified that he had information in a general way, a few days before the accident, that the chords were buckling. Talking with Birks about it less than half an hour before the collapse, Birks told him that there was a bend of 1⅝ ins., and that in his (Birks') opinion the chord was bent when it left the yard.

Twenty minutes before the accident, I saw A. H. Birks, the engineer inspector of construction for the Phoenix Bridge Co., and asked him if it was true that a bend had been discovered in chord 9 L of the anchor arm.

Q.—Did he admit there was such a deflection?

A.—He did, saying that the plates of the chord were bulging out 1⅝ ins. He added that in his opinion that


Sectional Elevation.
Top Plan and Section on Center Line.
Material of Chord:
Outer Rib
Inner Rib
Shop Splice:
Field Splice:
Pin Hole bored for 14" Pin
106' C. of Pin to End
46'6 9/32" End to C. of Pin
Top Lattice
Bott. Lattice
Diagonals L 4x3 1/2x 7/16"
Cross Struts 3 1/2 x 3 1/2 x 7/16"
Diaphragms D1 & D4
Diaphragm D2
Diaphragm D3
Diaphragm D5
Batten 67 1/2 x 1 x 9 1/2"
Batten 67 1/2 x 1 x 6 1/2"
Spl. Pl. 67 1/2 x 1 x 7 1/2"
ENG. NEWS.

PLAN AND ELEVATION OF LOWER CHORD MEMBER A 9 L, QUEBEC BRIDGE.

section of the chord was in that condition when it left the storage yard. I told him he had a right to his opinion, and I had a right to mine, and would not change it. He then got on the cars with the pieces they intended to erect and went on the bridge, where he met his death immediately afterward.

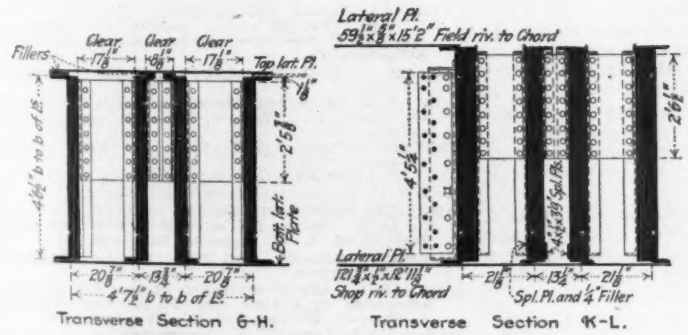
Q.—Is it your opinion that that chord was bent in the storage yard?

A.—Most certainly not. I was particularly interested in that chord section, for it had been in an accident in the storage yard, and had been repaired and was in perfect condition when it went to the bridge. I have examined the section of the chord in the wreck, and where it was repaired it did not break even in the collapse of the bridge.

The photograph of this chord, Fig. 19, p. 264 of our issue of Sept. 5, shows a part near the north end of the member, at the first panel point from the main post. Between the pin and the field-splice to chord 10, the member is little damaged, as Clark testified. The repair was made necessary by a fall; while the member was being hoisted in the yard, one of the hooks broke and the member fell, bending and breaking some of the plates at the end joining chord 10. The broken plates were replaced. The bent sections were straightened; heating was tried at first, but later a ram was used. After the repairs the member was passed by the inspectors as perfect.

The manner of fall of the bridge was described by a witness who was on the north shore. The foreman in charge of preparation on the north bank, Wickheiser, had his attention attracted by a grinding noise and cries. Looking up he saw the bridge moving. He looked at the main pier and "the plates seemed to be rolling up." The outer end of the bridge was dropping slowly. When the end was about 35 ft. from the water everything collapsed at once. The tops of the main posts were level with each other until the main crash; they seemed to be crushing down as they moved forward.

The testimony to date suggests that more or less general distress was exhibited by the chord sections of both anchor and cantilever arm some time, at least several days if not weeks, before the final failure. The cause of the collapse is narrowed more and more closely to the bottom chords. And except that a large bend was seen in chord A 9 L three days before the fall, there is nothing definite which would point more positively than before toward either anchor arm or cantilever arm, or left or right truss, as the seat of initial failure. The buckled condition of both A 9 L and A 9 R makes it more probable than before that stress conditions in all the chords had brought them close to their limit of strength.



Transverse Section G-H. Transverse Section K-L.

CROSS-SECTIONS OF LOWER CHORD MEMBER A 9 L, QUEBEC BRIDGE.

The coroner's inquest, which had been stopped when the government commission began work, in order to obtain the benefit of the commission's conclusions, was resumed last week (although the commission has not heard more than a portion of the evidence) and the jury rendered a verdict. They found that all the work on the bridge had been done with the greatest possible care.

We have been unable to establish the real cause of the collapse, but we think it our duty to declare that, according to the evidence furnished during the inquest, all necessary precautions were taken for the construction of the bridge without danger.

We reprint in corrected form and to enlarged scale the detail drawing of chord A 9 which appeared in our last issue, because of several minor errors in the drawing as originally made.

AN EXCEPTIONALLY SERIOUS WRECK occurred on the Boston & Maine R. R., near Canaan, N. H., on Sept. 15. Twenty-five passengers were killed and 27 persons, including some of the crew, injured. The wreck resulted from a head-on collision, in a thick mist at dawn, between a south-bound Quebec express and a north-bound freight. Those killed were all in the day coach, which was coupled between the baggage car and the smoker, behind which were the Pullmans; when the impact came the heavy sleepers forced the lightly-built day coach ahead, and the baggage car was forced through it, demolishing it.

The road is single-tracked, and is operated by the telegraph dispatching system, without the block system. While at this writing a conclusive statement has not been given out by road officials, reports indicate that confusion of telegraphic orders, somewhere between the dispatcher and the train crews, was the cause. Apparently it lies between the dispatcher at Concord and the operator at Canaan.

PREMATURE EXPLOSION of a charge for a 10-in. gun on the Japanese battleship "Kashima," on Sept. 9, killed five officers and 22 men and wounded four officers and 12 men. From press reports the disaster seems to have been somewhat of a class with the recent accident on the U. S. battleship "Georgia" on July 10, in which nine officers and men lost their lives and 12 were injured. The explosion, or "flare," occurred inside the shield of the after starboard 10-in. gun, after target practice off Kure. The hull of the vessel was not damaged.

ONE HUNDRED LIVES are reported lost by the burning of a Japanese steamer, in dispatches from Shanghai dated Sept. 18. The steamer, said to be the "Tafoo Maru," of the Osaka Shosen Kabushiki Co. line, was still burning at the time the dispatch was sent, in the Yangtsekiang River, 45 miles from Nanking; the reports, therefore, are not accurate as to the total number of casualties.

FIFTEEN THOUSAND POUNDS OF POWDER exploded on Sept. 14 in the glazing mill of the Equitable Powder Works at East Alton, Ill. While the force of the explosion was so great as to be felt 45 miles away, only one man was killed and one injured. Trees 14 ins. in diameter near the works were sheared off at their bases, and the glazing mill was totally demolished. The cause of the explosion is not known. The estimated damage to property is $15,000.

THE PIKE RUN BRIDGE, on the Chicago, Rock Island & Pacific Ry., near Muscatine, Iowa, collapsed on Sept. 4 while a freight train was crossing it. The bridge was a wooden structure; as it fell 11 cars from the middle of the train went into the stream, leaving the engine and five cars on one side and the caboose on the other.

THE "LUSITANIA," crossing the Sandy Hook bar at 9.03 A. M. on Friday, Sept. 13, 5 days, 1 hr. 33 min. after leaving Daunt Rock, beat all existing transatlantic records—except the ones made by the "Deutschland" and the "Kaiser Wilhelm II." The "Lusitania's" average in knots per hr. for the voyage was 22.87; the "Deutschland," in 1901, crossed by the Cherbourg course with an average of 23.51 knots per hr.; the "Kaiser Wilhelm II." made an average of 23.58 knots per hr. from New York to Plymouth.

There is no doubt among shipping men that the "Lusitania" will do greater things on subsequent trips, when she gets "tuned up." She has made a record for the time passengers were actually aboard ship, and with her 25-knot performance on her trial trip in view it is expected that the average records will also be beaten.

A 30-KNOT LINER is now announced. The Harland & Wolff Shipbuilding Co., of Belfast, has stated officially that it will undertake the construction of a vessel of that speed for transatlantic service. The projected vessel will be smaller than many that now enter the port of New York, as it is stated that she will be about 580 ft. long and of about 14,000 tons register. The conspicuous point in the plans as announced is that she will be driven by both turbines and reciprocating engines, i. e., there will be three screws, two driven by reciprocating engines and one by a turbine. The engine-driven screws will be located outside, as in a twin-screw vessel; and the turbine-driven screw will be in the center, just forward of the rudder post, as in a single-screw vessel. The reciprocating engines will be of the Harland & Wolff balanced type, quadruple-expansion.

Marine men are expressing skepticism as to this combination of turbines and reciprocating engines; the results of a trial cannot fail to be of great interest, in connection with that which has been bestowed upon the "Lusitania."

A SUSPENSION FOOT BRIDGE at Findlay, Ohio, fell on Sept. 15 while a crowd of people returning from a baseball game were passing over it. A hundred persons went down with the wreck, four of whom were seriously injured.

A DIRECT CABLE from New York City to Havana is to be laid for the Commercial Cable Co., to reduce the time of transmission now obtaining via the Florida route. The cable steamer "Silvertown" left London on Sept. 12 with 1,300 miles of cable on board.

NEW COLORS FOR RAILWAY SIGNAL LAMPS appear to be due for general adoption. The use of "white" lights to indicate safety, long conventional on American roads, involves several elements of danger: with the increase in population density and of settled tracts along the railroads, too many possible sources of white lights near the tracks exist, with consequent liability of their being mistaken by engine-runners for track signals; whether the colored glass used takes the form of lenses in pivoted lamps or of spectacles on a semaphore arm, the propensity of persons with firearms to select such things as targets introduces another possibility of false signals.

The tendency on a number of roads seems to be towards green for clear, yellow for caution (green's former place), and red for stop. For a number of years the Chicago & Northwestern Ry. has used green for clear; green and red, side by side, for caution; and red alone for stop. This, in view of the superior distinctness and individuality of these two colors at night, and the possibility of error in the nearness of yellow to red, seems safe practice if not so simple, perhaps, as the use of three colors singly. The Chicago, St. Paul, Minneapolis & Omaha Ry. has adopted this combination, and it is in use on the Belgian state railways. The other plan—wherein yellow figures as the caution color—is in use on the Harriman lines, the New York, New Haven & Hartford R. R., the Illinois Central R. R. and the Great Northern Ry. The Chicago, Burlington & Quincy Ry. and the New York Central lines have decided to adopt that plan, and the Pennsylvania R. R. has it under consideration.

The main point in the abolition of the so-called white light, and the use of distinct colors only in signaling, is that the showing of a white light at a signal point, from any cause—breaking of lenses or disks, or otherwise—will indicate something wrong, and a cautious engineman will stop. Possible inconveniences in the use of yellow or orange glass are on the side of safety; if a light yellow is mistaken for white, or a deep orange for red, it will only mean a stop. Breakage of a green lens or semaphore glass, whether by accident or design, would show a white light and also cause a stop.

REINFORCED GLASS TELEGRAPH POLES are being exploited by a company operating a factory at Grossalmerode, near Cassel, Germany, according to the U. S. Consular Reports. The poles are patented by an architect of Cassel. The glass is reinforced with interlaced and intertwined wire. The selling price is not definitely fixed, but it is stated that the concern is accepting $6 for a pole about 23 ft. long. One of the principal claims for the poles is their value in tropical countries, where the ravages of insects and effects of climate cause a short life of wooden poles. The German Imperial Post Department, controlling the telegraph and telephone lines, has ordered the trial of glass poles in one district.

GASOLINE MOTOR CARS are in use on the interurban line of the Aurora, De Kalb & Rockford Ry., in Illinois. They are four-wheel cars, 36 ft. long over the vestibules and seating 32 persons. A four-cylinder, four-cycle 60-HP. gasoline engine of the automobile type, with cylinders 7 × 7 ins., is set transversely across the frame, and has a planetary transmission gear. Two pinions with 20 teeth carry Morse silent driving chains, which run over 61-tooth spur wheels, one on each axle. The cast-iron wheels are 33 ins. diameter. The car weighs about 10 tons, of which the engine and transmission gear represent 1½ tons. The cars run at speeds of 20 to 35 miles an hour. They were built by the G. C. Kuhlman Car Co., of Cleveland, O., the engines being furnished by Batten & Co., of Harvey, Ill.

THE BRITISH COMPETITION OF TAR-SPREADING machines for laying road dust, rules for which were published at length in Engineering News of Feb. 7, 1907, resulted in the entry of eight machines, of which seven were tested. Twelve different preparations for laying dust were also submitted to test. The tests were made on May 22, 23 and 24, and on May 27, 1907, on selected roads in Middlesex and Berkshire Counties, England. The judges, whose names were given in our issue already

named, made known the successful candidates late in August, and promise a full report on the trials later, together with a general discussion of the use of tar on roads. The first prize for a tar-spreading machine went to Mr. Thomas Aitken, M. Inst. C. E., County Surveyor, Cupar, Fife, Scotland, for his patent pneumatic tar sprayer. Mr. Aitken is the author of a commendable British book on "Road-Making and Maintenance." An article entitled "The Application of Tar to Macadamized Roads," abstracted from a recent society paper by Mr. Aitken, was published in our issue of Aug. 22, 1907. In the course of that article a tar-spraying machine devised by Mr. Aitken, and presumably like the one just awarded the prize, was described. The second award in the competition was to a company known as Tarspra, Limited, of 20 Victoria St., London, S. W. Its machine consists of a tar-spraying van of 700-gal. (Imp.) capacity, attached to a Thornycroft motor-van. A pump, geared to the wheels of the van, forces tar through atomizing nozzles. Ordinary coal-gas tar, sprayed hot or cold, was used. The machine has been used in Birmingham, Maidstone, and a number of other places in England. The best preparation of tar for road purposes was declared by the jury to be Clare's Patent Tar Compo, made by R. S. Clare & Co., Ltd., Stanhope St., Liverpool, England. This is a purified tar, treated to give a uniform consistency in winter and summer. The first prizes consisted of 100 guineas in gold (about $500) and a gold medal. The second prize was 50 guineas and a silver medal. Descriptions of all the machines and materials entered in the competition appeared in the London "Surveyor" for May 31, 1907.

PROGRESS ON THE WATER-WORKS, SEWERAGE and drainage systems of New Orleans was outlined by Mr. F. S. Shields, Secretary to the Water and Sewerage Board, in an article published in the New Orleans "Daily States" for Aug. 31, 1907. Contracts have been let for water-works, pumping and purification plants, to be completed by Jan. 1, 1909, and for some 200 miles of water mains, and work is well under way. The water-works construction completed and under contract represents an expenditure of some $5,400,000, of which $2,200,000 has already been earned by the contractors. Bids for 254 additional miles of mains, to be laid within 13 months, were to be received on Sept. 4. On the sewerage system, 277 miles of sewers have been laid, the main pumping station has been in use (lifting ground water chiefly) since October, 1906, and the sub-stations have also been completed. There remain 110 miles of sewers to be contracted for, but it is expected that the work will be done by the close of 1908. The expenditures for sewerage totaled $4,267,000 to Aug. 1, 1907. Only 650 sewer connections have been made thus far, as compared with some 7,000 connections with the old works of the New Orleans Water-Works Co. (which serve only a part of the city). Portions of the drainage system have been in operation for some time, including 48 of 80 proposed miles of canals, and parts of the main power station and of the several pumping stations.

ELECTRIC RAILWAYS in the United States aggregated 36,212 miles at the end of 1906, with 720 miles of line having cable, steam or horse traction; the grand total was 36,932 miles. The equipment included 66,206 electric motor cars, 1,084 steam or cable cars, and 17,819 trail cars (including horse cars). Canada had 1,073 miles of electric railway, and 77 miles with cable, steam or horse traction. Cuba had 187 miles, and the U. S. insular possessions (Porto Rico, Hawaii and the Philippine Islands) had 119 miles of electric railways. The statistics published in the "American Street Railway Investments" shows that the capital stock and funded debt of the lines in the United States aggregated $2,040,000,000 and $1,725,370,000, respectively.

BRICK, TILE AND CLAY PRODUCTS in the United States aggregated $161,032,722 in value for the year 1906, according to a tabular statement of the U. S. Geological Survey. Some of the items in this total are tabulated below:

Common brick (10,027,039 M.)	$61,300,696
Front brick (617,469 M.)	7,895,323
Vitrified paving brick or block (751,974 M.)	7,857,768
Drain tile	6,543,289
Sewer pipe	11,114,967
Architectural terra cotta	5,739,460
Fireproofing	3,652,181
Hollow-building tile or blocks	934,357
Tile (not drain tile)	4,634,898
Firebrick (770,839 M.)	14,206,868

MICHIGAN GAS ASSOCIATION.—The fifteenth annual meeting will be held at Battle Creek on Sept. 18, 19 and 20. Papers which are scheduled for presentation are as follows: "Some Notes on Obtaining All-the-Year, All-Gas Kitchens," J. R. Hunting; "A Brief Record of Progress in Fuel Briquette Manufacturing at Detroit," W. S. Blauvelt; "Studies in the Manufacture of Coal Gas," Alfred H. White and Fred. E. Parke; "Ways and Means to Increase Gas Sales," E. J. L'Esperance; "A New Method of Condensing and Scrubbing," Wm. Seymour; Report of Committee—"Rules and Suggestions for Doing Away with Accidents Around Gas Properties," Herman Russell, Chairman; Report of Committee—"Michigan Gas Association Fellowship at the University of Michigan," Henry W. Douglas, Chairman.

RAILS WEIGHING ABOUT 120 LBS. PER YD. are being tried on the Belgian State Railways. It is considered that the present 80-lb. rails are not sufficiently heavy and strong for main line traffic, in view of the great increase in weight of locomotives and cars. Some 100-lb. rails are in use, but mainly at turnouts and crossings. With the new rails, heavier splices are used and the ties are spaced 20 to 24 ins. c. to c., instead of 32 ins. The rails are all of the tee section.

PERSONALS.

Mr. J. F. Welborn has resigned as President of the Colorado Fuel & Iron Co.

Mr. L. J. Wagner was elected Superintendent of the Rome (Ga.) Water Works on Sept. 5.

Mr. Jas. C. Van Trump has been appointed Superintendent of the Wilmington, Del., Water Department.

Mr. E. K. Woodward, Chief Engineer of the Pere Marquette R. R., has resigned. Mr. J. F. Deimling succeeds him.

Mr. W. J. Buchanan has resigned as Master Car Builder of the Bessemer & Lake Erie R. R. Mr. F. W. Dickinson succeeds him.

Mr. F. W. Allen, Assistant Superintendent of the Great Northern Ry. at Minot, N. Dak., has resigned. Mr. R. A. McCandless succeeds him.

Mr. C. E. Grafton, M. Am. Soc. C. E., has opened an office at New Cumberland, W. Va., for consulting practice in civil and mining engineering.

Mr. R. P. C. Sanderson, Superintendent of Motive Power of the Seaboard Air Line, has resigned to accept the same position with the Virginia Ry.

Mr. J. C. Ramsey, Master Mechanic of the St. Louis, Watkins & Gulf Ry., has resigned. Mr. S. P. Spangler succeeds him, with headquarters at Lake Charles, La.

Maj. E. E. Winslow, in command of the Engineer School at Washington Barracks, D. C., has been assigned to temporary duty in the office of the Chief of Engineers.

Mr. L. C. Hartley, Assistant Engineer of Maintenance of Way on the Pennsylvania Lines West of Pittsburg, has been appointed Signal Engineer of the Chicago & Eastern Illinois R. R.

Mr. H. P. Boardman recently resigned as Engineer in charge of branch canals for the Sanitary District of Chicago, to become Professor of Civil Engineering in the University of Nevada, at Reno.

Mr. Edward Quebbeman has been appointed St. Louis agent of the Universal Portland Cement Co., with offices in the Chemical Building. He succeeds Mr. J. C. Van Doorn, who goes to the Minneapolis office.

Mr. Thomas Yeager has been appointed Master Mechanic of the Illinois Southern Ry., with office at Sparta, Ill., to succeed Mr. M. W. Fitzgerald, assigned to other duties. The appointment was effective Sept. 1.

Mr. Lucius T. Gibbs has been appointed Electrical Engineer of the Baltimore & Ohio R. R., with offices at Baltimore. He succeeds Mr. W. D. Young, who resigned. Mr. Gibbs was formerly connected with the Westinghouse Electric & Mfg. Co.

Mr. Walter E. Emery, Roadmaster of the Chicago & Northwestern Ry. and Secretary of the Roadmasters' and Maintenance of Way Association, has been appointed Engineer of Maintenance of Way of the Chicago & Alton Ry., with office at Kansas City, Mo.

Mr. H. C. Ettinger was appointed on Sept. 15 to succeed Mr. E. F. Needham as Master Mechanic of the Decatur and Springfield divisions of the Wabash R. R., with headquarters at Springfield, Ill. Mr. Needham's promotion we announced here on Sept. 5.

Mr. N. E. Newton, Assoc. M. Am. Inst. E. E., formerly of the Shop Superintendent's staff at the New York house of the Western Electric Co., has been made Shop Superintendent of the Montreal works of the company (known as the Northern Electric Co.).

Judge E. H. Gary, of the U. S. Steel Corporation, it is reported, is to become the managing head of the Allis-Chalmers Co., of Milwaukee. He has been connected with the latter company since its formation, but heretofore has not taken active part in its management.

Mr. W. H. Whittenton, Superintendent of the Missouri division of the Chicago, Rock Island & Pacific Ry., has been appointed General Superintendent over the Choctaw district, with offices at Little Rock. He succeeds Mr. H. M. Hallock, whose resignation we announced last week.

Mr. W. H. Waugh, Assoc. M. Am. Soc. C. E., Chief Engineer of the Shenango Traction Co., Greenville, Pa., has been appointed Chief Engineer of the Little Rock & Pine Bluff Traction Co., Little Rock, Ark. Mr. Waugh is still retained by the Shenango Traction Co. as Consulting Engineer.

Mr. A. A. Knudson, M. Am. Inst. E. E., of New York City, has been appointed to act as an expert in connection with litigation now in progress between the Toronto Street Ry. Co. and the Toronto Gas Co. Messrs. W. E. Foss, of Boston, and L. C. Anderson, of Franklin, O., will serve with Mr. Knudson.

Mr. James L. McQuarrie, Assistant Chief Engineer of the Western Electric Co., has removed his headquarters from the Chicago to the New York offices of the company. Mr. F. L. Gilman, formerly in charge of the engineering department at New York, is now Assistant Shop Superintendent, reporting to Mr. Henry F. Albright, M. Am. Inst. E. E., Shop Superintendent.

Prof. L. G. Carpenter, of the Agricultural College of Colorado, Fort Collins, has been appointed by the Lieutenant-Governor and Executive Council of British Columbia a member of a commission to examine into and report on irrigation in that province. The other member is Hon. F. J. Fulton, K. C. Among the results is expected to be a government measure making a complete revision of the water acts, and introducing a comprehensive system. The commission has power to call for witnesses and documents, and to take sworn evidence. It has visited the region at present irrigated or proposed to be irrigated; inspected systems and plans, and especially attempted to find the difficulties which arise from the present act.

Prof. E. R. Dewsnup, of the University of Chicago, has been appointed Professor of Railroad Administration and Management in the new College of Railway Engineering at the University of Illinois. He is English born, of American parents; his education was received at the University of Manchester and the Royal Technical College, of Manchester. After graduation he made a study of railway operation, construction and management in the United Kingdom, France and Germany, and served as a railway official on an English road. He then spent a year in this country, making comparative studies. Three years ago the late President Harper brought him to this country permanently and placed him in charge of the railway courses of the University of Chicago. Prof. Dewsnup has published many articles on railway subjects.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Sept. 30-Oct. 4. Thirty-fifth annual meeting at Atlantic City, N. J. Secy., Dr. Chas. O. Probst, Columbus, Ohio.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Oct. 1-4. Annual meeting at Detroit. Secy., Geo. W. Tillson, 831 Ocean Ave., Brooklyn, N. Y.

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.
Oct. 8. Annual meeting at Washington, D. C. Secy., Edw. A. Moseley, Interstate Commerce Commission, Washington, D. C.

RAILWAY SIGNAL ASSOCIATION.
Oct. 8-10. Twelfth annual meeting at Milwaukee. Secy., C. C. Rosenberg, Lehigh Valley R. R., South Bethlehem, Pa.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION.
Oct. 8-10. Nineteenth annual convention at Atlanta, Ga. Secy., J. D. Farasey, Forest St. and Erie Ry., Cleveland, O.

INTERNATIONAL ASSOCIATION OF FIRE ENGINEERS.
Oct. 8-11. Thirty-fifth annual convention at Washington, D. C. Secy., Jas. McFall, Roanoke, Va.

AMERICAN ELECTROCHEMICAL SOCIETY.
Oct. 10-12. Annual fall meeting at New York City. Secy., Prof. J. W. Richards, Bethlehem, Pa.

AMERICAN STREET AND INTERURBAN RAILWAY ASSOCIATION.
Oct. 14-18. Annual convention of this and affiliated association at Atlantic City, N. J. Secy., Bernard V. Swenson, 29 West 39th St., New York City.

AMERICAN STREET AND INTERURBAN RAILWAY ENGINEERING ASSOCIATION.
Oct. 14-16. Annual convention at Atlantic City, N. J. (See preceding item.) Secy., S. W. Mower, Southwestern Traction Co., London, Ont.

ASSOCIATION OF RAILWAY SUPERINTENDENTS OF BRIDGES AND BUILDINGS.
Oct. 15-17. Annual meeting at Milwaukee. Secy., S. F. Patterson, Concord, N. H.

AMERICAN GAS INSTITUTE.
Oct. 16-18. Second annual meeting at Washington, D. C. Secy., Jas. W. Dunbar, New Albany, Ind.

ROADMASTERS' AND MAINTENANCE OF WAY ASSOCIATION.
Nov. 11-14. Twenty-fifth annual convention at Chicago. Secy., W. E. Emery., C. & A. Ry., Kansas City, Mo.

AMERICAN MINING CONGRESS.
Nov. 11-16. Tenth annual convention at Joplin, Mo. Secy., J. F. Calbreath, Jr., Denver.

AMERICAN CIVIC ASSOCIATION.
NATIONAL MUNICIPAL LEAGUE.
Nov. 19-21. Joint convention at Providence, R. I. Secy., Clinton R. Woodruff, North American Building, Philadelphia.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.
Nov. 22-23. Annual meeting at New York City. Secy., W. J. Baxter, 29 West 39th St., New York City.

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